HOUSATONIC RIVER FLOOD CONTROL

DANBURY, CONN.

LOCAL PROTECTION

STILL RIVER, CONNECTICUT

DESIGN MEMORANDUM NO. 1

HYDROLOGY AND HYDRAULIC ANALYSIS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

AUGUST 1968

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-H

29 August 1968

SUBJECT: Danbury Local Protection Project, Still River, Housatonic River Basin, Connecticut, Design Memorandum No. 1 - Hydrology & Hydraulic Analysis

Chief of Engineers
ATTN: ENGCW-E

There is submitted herewith for review and approval Design Memorandum No. 1, Hydrology and Hydraulic Analysis for Danbury Local Protection Project, Still River, Housatonic River Basin, in accordance with ER 1110-2-1150.

FOR THE DIVISION ENGINEER:

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1 Incl
as (5 cys)

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Chief, Engineering Division

DESIGN MEMORANDA INDEX

Number	Title	Date Submitted	Date Approved
1	Hydrology and Hydraulic Design	Aug 1968	
2	General Design (Including Site Geology)		
3	Concrete Materials		
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5	Structures		

DANBURY LOCAL PROTECTION PROJECT

STILL RIVER
HOUSATONIC RIVER BASIN
CONNECTICUT

DESIGN MEMORANDUM NO. 1

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DANBURY LOCAL PROTECTION PROJECT

STILL RIVER
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DESIGN MEMORANDUM NO. 1

1. INTRODUCTION

a. Purpose. This memorandum presents the hydrologic and hydraulic criteria applicable to the design of the Danbury Local Protection Project on the Still River in Danbury, Connecticut. Part I, Hydrology, includes sections on climatology, streamflow, flood history and derivation of the standard project flood. Part II, Hydraulics, presents hydraulics of the channels including water surface profiles, velocities and freeboard design. Interior drainage for this project will be presented in a separate design memorandum at a later date.

b. Project authorization. The Danbury Local Protection Project was recommended in "Report on Review of Survey for Flood Control, Housatonic River Basin," dated 13 September 1963. The project was authorized by the Flood Control Act of 1965, Public Law 89-298, dated 29 October 1965.

c. Departure from authorized plan. The original project plan has been changed to include approximately 3,600 feet of concrete rectangular channel in place of an improved trapezoidal channel previously recommended. This change improves hydraulics in the reach and is economically justified through savings in real estate and bridge costs. Economics of the change will be presented in Design Memorandum No. 2, "General Design."

In Appendix B, "Hydrology and Hydraulics" of the above referenced Housatonic Report, it was noted that a hydraulic model study of the project was desirable unless it was found possible to improve hydraulic features in final design. Hydraulics of the project are much improved with the adoption of the concrete rectangular channel and a model study is now considered unnecessary.

d. Project description. The project is located on the Still River within the city of Danbury, Fairfield County, Connecticut. The improvement begins about 300 feet downstream from White Street bridge, extends for 1.3 miles along the river and terminates approximately 700 feet downstream from Triangle Street bridge. The project will consist of the construction of 1.3 miles of new and/or improved river channel, including low dikes where required and channel protection. Three railroad bridges and two highway bridges will be replaced with new structures, one private roadway bridge will be removed and one railroad bridge modified. The general plan of the project is shown on plate 1-10. The project will complete improvement of the river channel between existing improvements made upstream by an urban renewal project and downstream by the State of Connecticut. Protection will be provided against the standard project flood for approximately 90 acres of land within the city of Danbury.

e. Coordination with local authorities. The general design has been developed with the knowledge and concurrence of the officials of the city of Danbury who will be furnished copies of this design memorandum after approval for retention and comment.

PART I - HYDROLOGY

2. DESCRIPTION OF STILL RIVER WATERSHED

The Still River, a principal tributary to the Housatonic River, is located in the southwest corner of the State of Connecticut. The headwaters of the Still River lie about 3 miles west of Danbury, Connecticut where it has its source in Lake Kenosia. From this source the river travels generally eastward through the center of the developed sections of Danbury and then northward to Lanesville, Connecticut where it joins the Housatonic River. The total drainage area of the Still River is 71.5 square miles. At the Cross Street bridge in Danbury the basin area is 38.3 square miles, which essentially encompasses the entire upper portion of the Still River watershed. The topography of the upper portion of the "fan-shaped" watershed can generally be characterized as hilly with rather steep slopes while the lower portion is narrow and has mild slopes. The river channel gradient varies from approximately 26 feet per mile in the upper reaches of the watershed to 6 feet per mile in the lower portions. Maps of the Housatonic and Still River watersheds are shown on plates 1 and 2.

3. CLIMATOLOGY

a. General. The Still River basin has a variable climate characterized by frequent but usually short periods of precipitation. The basin lies in the path of a weather pattern referred to as the "prevailing westerlies" which often include cyclonic disturbances that cross the country from the west or southwest. It is also exposed to occasional coastal storms, some of tropical origin, that travel northward along the Atlantic seaboard. In late summer and autumn these storms occasionally attain hurricane intensity. Due to its proximity to the Atlantic Coast, the Still River basin escapes the severity of cold and depth of snowfall that occur in the more northern portions of the Housatonic River basin.

b. Temperature. Mean monthly temperatures in the Still River basin vary widely throughout the year. The mean annual temperature is approximately 49° Fahrenheit with the mean monthly temperature varying from 26.6° Fahrenheit in January to 71.3° F. in July. The minimum recorded temperature at Danbury is -16° F.; the maximum recorded temperature is 101°

Fahrenheit. Freezing temperatures can be expected from November through March. The mean, maximum and minimum temperatures recorded for each month at Danbury are shown in table 1-1.

c. Precipitation. The mean annual precipitation over the Still River watershed is approximately 46 inches and is quite uniformly distributed throughout the year. The maximum and minimum annual precipitation at Danbury for 27 years of record through 1966 are 67.15 and 31.85 inches, respectively. During the month of October 1955 a total of 17.64 inches of rain fell establishing the record monthly maximum. It was also during this month in 1955 that the flood of record was established when 12.08 inches of rain fell during the period 14 to 17 October. Table 1-2 summarizes the precipitation records in Danbury.

d. Snowfall. The average annual snowfall over the watershed is approximately 40 inches. Snow usually occurs over the 6-month period from November through April with amounts for the months of December, January and February usually accounting for almost 75 percent of the total during this period. Monthly and annual average snowfall for 25 years of record at Danbury are tabulated in table 1-3.

e. Storms. The Still River watershed has experienced storms of four general types, namely:

(1) Extratropical continental storms which move across the basin under the influence of the "prevailing westerlies."

(2) Extratropical maritime storms which originate and move northward along the eastern United States coast.

(3) Storms of tropical origin, some of which attain hurricane magnitude.

(4) Thunderstorms produced by local convective activity or by more general frontal activity.

The most severe storms have been of tropical origin and occur during late summer and early autumn. The most notable recent storms in the Still River basin occurred in March 1936, September 1938, December 1948, August and October 1955 and September 1960. Of these, only the March 1936 and December 1948 storms were not associated with tropical activity. Mass rainfall curves for the storms of August and October 1955 are shown on plates 3 and 4.

4. RUNOFF

a. Discharge records. Records of river stages and streamflows at a gaging station on the Still River near Lanesville, Connecticut (D. A. = 68.5 square miles) have been published by the U. S. Geological Survey (USGS) since 1931. These records, in general, are good. In addition to

TABLE 1-1

MONTHLY TEMPERATURE RECORD
(Degrees Fahrenheit)

Danbury, Connecticut
Elevation 510 feet msl
24 Years of Record

Month	Mean	Maximum	Minimum
January	26.6	71	-16
February	29.0	70	-16
March	36.5	80	- 4
April	47.7	91	15
May	57.9	94	25
June	66.5	97	35
July	71.3	101	40
August	69.4	100	37
September	62.2	92	23
October	53.4	91	19
November	42.2	82	0
December	30.1	68	-11
ANNUAL	49.4	101	-16

TABLE 1-2

MONTHLY PRECIPITATION RECORD
(in inches)

Danbury, Connecticut
Elevation 510 feet msl
27 Years of Record

Month	Mean	Maximum	Minimum
January	3.42	7.68	0.72
February	3.27	8.04	1.22
March	3.70	8.68	1.74
April	3.96	8.17	1.34
May	4.03	8.58	1.39
June	3.37	6.54	0.53
July	4.41	11.30	0.92
August	4.37	16.34	1.19
September	3.73	13.56	0.26
October	3.57	17.64	0.24
November	4.69	8.56	1.28
December	3.88	7.88	0.72
ANNUAL	46.40	67.15	31.85

TABLE 1-3

MONTHLY SNOWFALL RECORD
(Average Depth in Inches)

Danbury, Connecticut
Elevation 510 feet msl
25 Years of Record

Month	Snowfall
January	10.5
February	10.2
March	7.5
April	1.3
May	-
June	-
July	-
August	-
September	-
October	-
November	1.8
December	8.7
ANNUAL	40.2

the recordings obtained at this gaging station, the USGS has published maximum discharge values for the two largest floods of record at a point on the Still River (D.A. = 38.3 square miles), 0.6 mile downstream from its confluence with Sympaug Brook. These values were derived by slope-area measurement and by computation of flow through a bridge opening. Flow data at the Lanesville gaging station are summarized in table 1-4. The mean daily discharges for the period 1931-1966 are shown on plates 22 through 25.

TABLE 1-4

STREAMFLOW RECORDS

Location	Drainage Area (sq.mi.)	Period of Record	Discharge (cfs)		
			Mean	Maximum	Minimum
Still River near Lanesville	68.5	1931-1966	116	7,980* (10-16-55)	5.0* (10-20-46)

* Momentary discharge

b. Streamflow data. The average annual runoff from the Still River basin at Lanesville, based on 35 years of record, is 116 cfs, equivalent to 23 inches of runoff from the tributary basin area of 68.5 square miles. This represents approximately 50 percent of the average annual precipitation. Mean, maximum and minimum monthly and yearly runoff in cfs for the period of record at the Lanesville gage is shown in table 1-5.

5. HISTORY OF FLOODS

a. General. Floods in the Still River may occur during any season of the year as a result of either intense rainfall over the watershed or from rainfall in conjunction with melting snow such as the flood of March 1936. However, the greatest floods have developed from rainfall alone when rainfall intensity and the antecedent conditions rather than the volume of rainfall were the determining factors. This is evident when the storms of August and October 1955 are compared. The October storm produced 80 percent as much rainfall as that of the August event but owing to greater antecedent precipitation and a shorter duration, the October storm resulted in a peak discharge 100 percent larger in magnitude.

b. Floods of record. The Still River basin has experienced four major floods during the 35-year period of record. These floods, the magnitudes of which are shown in table 1-6, are described briefly in the following paragraphs. Hydrographs for the August and October 1955 floods are shown

TABLE 1-5

MONTHLY RUNOFF
OCTOBER 1931 - SEPTEMBER 1966
(cubic feet per second)

Still River Near
Lanesville, Connecticut
DA = 68.5 square miles

Month	Mean	Maximum	Minimum
January	140.3	299	33.1
February	148.1	318	49.6
March	222.5	467	110.0
April	193.8	352	68.9
May	123.7	215	45.2
June	81.1	229	33.9
July	59.6	203	24.9
August	64.1	439	18.8
September	60.3	380	18.4
October	72.0	642	18.3
November	110.5	484	23.7
December	121.8	258	31.9
ANNUAL	116.4	197*	55.4**

* Water year 1952
** Water year 1966

on plates 3 and 4. The high watermarks at various points along the river in Danbury during the October 1955 flood are shown on plate 10.

TABLE 1-6

MAJOR FLOODS
OCTOBER 1931 - SEPTEMBER 1966

Calendar Year	Date	Peak Discharge, cfs Measured at Lanesville	Computed at Danbury*
1955	16 October	7,980	5,000
1955	19 August	3,920	2,770
1938	22 September	3,590	
1936	12 March	3,260	

* Values obtained at Cross Street bridge from computations by the USGS

(1) March 1936. The March 1936 floods resulted from two closely occurring storms during the periods from the 9th through the 13th and the 17th through the 22nd. The hydrograph at the Lanesville gaging station shows two distinct peaks. The magnitude of the first peak is twice as large as that of the second even though the rainfall for both storms differed by only one-half inch. This was caused by two basic factors: (a) most of the precipitation in the first storm fell within a 72-hour period, whereas the second storm was spread over a 120-hour period; and (b) the first storm was accompanied by generally rising temperatures which produced considerable snowmelt runoff.

(2) September 1938. The flood of September 1938 was produced by a hurricane storm following a period of greater than average precipitation. The heavy downpour of rain accompanying the hurricane of 21 September fell on ground already saturated by prior rains. Most of the natural storage in lakes, swamps and river channels was filled to capacity and did little to reduce the high rates of runoff. The flood hydrograph reached its peak on 22 September.

(3) August 1955. The flood of August 1955 was generated by two hurricane storms occurring within a few days of each other. The first storm, hurricane "Connie", maintained a rather uniform rainfall rate during the period 11-14 August and, owing to dry antecedent ground conditions,

did not produce an exceptional amount of runoff. However, the second storm, hurricane "Diane", produced intense rainfall on the 18th and 19th which combined with the saturated ground conditions and full ponds and reservoirs, produced a major flood from the Still River watershed.

(4) October 1955. The greatest flood of record in the Still River basin occurred in October 1955, only two months after the August flood, the second largest of record. The storm producing the flood, although not a hurricane, was of tropical origin and brought a record amount of precipitation to the basin. Rain fell over the 4-day period from the 14th through the 17th and totaled 12.08 inches at Danbury. The maximum daily amount was 6.10 inches on the 16th. Again, the high rainfall intensity combined with saturated antecedent ground conditions and little or no available storage resulted in exceptional amounts of runoff from the basin. The flood hydrograph peaked on the river at both Danbury and Lanesville on 16 October.

6. FLOOD FREQUENCY

The frequency or percent chance of occurrence of flood discharges in the Still River basin was determined from data recorded over a 35-year period at the U. S. Geological Survey stream gaging station at Lanesville. Frequency analyses were made in accordance with procedures set forth in ER 1110-2-1450, "Hydrologic Frequency Estimates." Based on a regional analysis, the skew coefficient adopted for the basin was 1.0. From the discharge-frequency relationships developed for the river at Lanesville, a discharge-frequency curve was also derived for the river at Triangle Street in Danbury. The discharge-frequency curves for both locations are shown on plate 9.

7. ANALYSIS OF FLOODS

The record floods of August and October 1955 were analyzed in detail in order to determine the hydrologic characteristics of floods in the Still River. Runoff hydrographs at Danbury were derived from the recorded peak discharges at Triangle Street and by drainage-area relationships applied to the observed hydrographs at Lanesville. Adjustments were made to account for the slight difference in rainfall between the upper and lower portions of the basin. Analyses of the floods are shown on plates 3 through 7.

8. STANDARD PROJECT FLOOD

a. General. Standard project floods were developed for the Still River at Cross and Triangle Streets in Danbury and for the intervening tributary, Sympaug Brook. Development of the SPF hydrographs included derivation of unit hydrographs from analyses of the August and October 1955 floods at Cross Street and the application of the standard project storm excess rainfall in accordance with procedures described in Civil Works Engineer Bulletin 52-8, as revised.

b. Unit hydrograph analysis. Three-hour unit hydrographs were developed from the floods of August and October 1955 for the Still River at Cross Street in Danbury. The two derived hydrographs together with the adopted 3-hour unit hydrograph are shown on plate 7.

c. Flood discharges. The standard project flood hydrograph for the 38.3 square mile drainage area above Cross Street was derived by applying the standard project storm rainfall excess to the adopted unit hydrograph. The resultant flood hydrograph at Cross Street had a peak ordinate of 7,800 cfs. Utilizing the derived hydrograph at Cross Street, an SPF hydrograph was determined for Sympaug Brook by drainage area and peak discharge relationships.

The SPF hydrograph for Sympaug Brook was subtracted from the Cross Street hydrograph resulting in a peak SPF discharge on the Still River above Sympaug Brook of 6,900 cfs. The derived SPF hydrographs for the Still River at Cross Street, Sympaug Brook and the Still River upstream of Sympaug Brook are shown on plate 8. The peak SPF discharge of 6,900 cfs was used as the design discharge for the Danbury Local Protection Project.

d. Effect on improvements by others. The recently constructed Urban Renewal channel improvement, to which this project will connect at station 9+20, was designed to pass the SPF of 6,900 cfs. At its downstream end (station 72+60) the Danbury Local Protection Project will join the existing improved Still River channel which was built by the State of Connecticut. This channel was designed to pass the October 1955 flood of record discharge (5,000 cfs) downstream of Sympaug Brook. Modifications will be made to a portion of the reach previously improved by the State of Connecticut to preclude the need for higher dikes upstream. The project design flood will pass through the lower reach of the state-improved channel with minor nuisance damage.

PART II - HYDRAULIC ANALYSIS

9. GENERAL

The Danbury Local Protection Project has two hydraulically separate reaches, a 3,615-foot long concrete rectangular channel and a 2,725-foot riprapped trapezoidal channel. A general plan illustrating the two reaches is shown on plate 10. Included under hydraulics of the concrete channel are analyses of the inlet and outlet transitions. Analysis for riprap design is similarly presented under hydraulics for the trapezoidal channel.

10. CONCRETE RECTANGULAR CHANNEL

a. Description. A concrete rectangular channel, 3,430 feet long, 40 feet wide and 13 feet deep, will be constructed to convey the Still River from station 10+20 to station 44+50. This channel will have an invert slope of 2 feet per 1,000 feet with invert elevations at the above stations of 358.3 and 351.4 feet msl, respectively. Plans and profiles of the concrete channel are shown on plates 11, 12 and 13.

b. Manning's "n". Manning's "n" for the concrete channel was found to range from 0.0135 to 0.0155 using HDC 631 and 631-1, revision 1-68, with a maximum and minimum "k" for concrete of 0.007 and 0.002, respectively. An "n" of 0.015 was adopted for determining design grades of walls and an "n" of 0.013 was assumed to insure development of a hydraulic jump in the outlet stilling basin.

c. Channel slope. The adopted channel slope of 0.002 was based on both engineering analysis and judgment. With the adopted slope and an "n" of 0.015, normal depth for the design flow of 6,900 cfs will be 10.7 feet or 10 percent greater than critical depth. With an "n" of 0.013 the flow would be approximately critical at a depth of 9.7 feet with a velocity of 17.8 feet per second. It was realized that in the event that "n" was nearer 0.013, normal flow would approach critical depth resulting in a turbulent flow condition. However, the adoption of a flatter slope would result in increased wall height and because the natural land grade in the area is between 0.002 and 0.0025 a lesser slope would create problems in providing for interior drainage into the channel at the downstream end. It was therefore concluded that the additional freeboard due to shallower depth of flow for lesser "n" values would be adequate to confine any added turbulence and the more economical slope of 0.002 was adopted. The standard project flood has a frequency of once in 250 years and its peak flow of 6,900 cfs would last only for a 2-hour period.

d. Inlet transition. A 100-foot long transition section at the inlet, station 9+20 to station 10+20, will converge the flow from the existing 72-foot wide upstream urban renewal channel to the 40-foot wide rectangular channel. Convergence of 32 feet in 100 results in each wall having an angle of convergence of 9.1 degrees. In the transition the invert will drop 0.13 foot with a slope of 0.0026 for the first 50 feet and then 6.4 feet uniformly in the remaining 50 feet, resulting in a slope of 0.128.

The existing upstream urban renewal channel was designed to convey the same design discharge of 6,900 cfs under normal subcritical flow conditions at a velocity of 9 feet per second and a depth of 10.8 feet. The proposed inlet transition is hydraulically designed to maintain these same flow conditions in the upstream channel. The design discharge will enter the inlet transition at a normal depth of 10.8 feet and a velocity of 9 feet per second, accelerate to critical depth and velocity at the change in invert slope and continue to accelerate throughout the remainder of the transition to a velocity of 25.1 feet per second and a depth of 6.9 feet at the start of the concrete rectangular channel.

The slope of 0.002 in the concrete rectangular channel will not sustain supercritical conditions and flow will return to subcritical. The distance downstream at which flow will return to subcritical will vary with the discharge in the river. A curve of theoretical distance to hydraulic jump versus discharge is shown on plate 17. Hydraulic computations were based on a Manning's "n" of 0.015 and a convergence loss coefficient of 0.2 in the inlet transition. It is noted that all hydraulic jumps for the entire range of discharges would be classified as "undular" because Froude numbers do not exceed 1.7 (V. T. Chow, "Open-Channel Hydraulics,"1959, page 395). Manning's "n" is of little significance in the design of the inlet transition. However if an "n" of 0.013 is assumed rather than 0.015, flows will not decelerate to subcritical but only to critical and no jump will occur.

e. Outlet transition. An outlet transition will be built between stations 44+50 and 45+35 where flows will be stilled before discharging into the trapezoidal channel. The stilling basin transition will vary uniformly from the 40-foot wide channel to a width of 55 feet in a distance of 35 feet. A corresponding drop in the invert of 2.8 feet takes place uniformly over this distance resulting in an invert slope of 0.080 and a lowering of the channel from elevation 351.4 to 348.6. The remaining 50 feet of the basin consists of a 55-foot wide rectangular section with a level bottom at elevation 348.6 terminating with a 2-foot high dentated sill. A plan and profile of the outlet basin is shown on plate 19. Flows will pass from normal depth in the channel to critical flow at the entrance to the outlet transition and continue to accelerate through the diverging section of the basin. Within the basin the flow will jump hydraulically to the conjugate tailwater depth produced by the downstream trapezoidal channel.

The design discharge of 6,900 cfs will have a critical flow depth at the basin entrance of 9.7 feet and a velocity of 17.8 feet per second. It will then accelerate to a velocity of 26.2 feet per second at the toe of the transition and then jump to the conjugate depth and velocity of

12.6 feet and 6.8 feet per second, respectively.

Further analyses indicated that the design discharge of 6,900 cfs is the most severe hydraulic criteria for the design of the outlet basin. It was determined that the downstream tailwater will provide a submergence effect for all lesser flows. All jumps in the outlet basin would be classified as "weak jumps" since Froude numbers will not exceed 2.5.

f. Water surface profiles. Water surface profiles were determined, both for "drawdown" in the inlet and outlet structures and "backwater" in the concrete rectangular channel, using computer program 22-J2-L212 furnished by the Sacramento Hydrologic Engineering Center. The method used by this program is generally similar to method 1 described in EM 1110-2-1409, 7 December 1959, "Backwater Curves in River Channels." Computed water surface profiles for the concrete rectangular channel and the terminal structures are shown on plates 11, 12 and 13.

g. Velocities. Maximum normal flow velocity of 16.1 feet per second in the concrete rectangular channel will occur with the design discharge of 6,900 cfs. Normal flow curves relating depth, velocity and discharge in the concrete rectangular channel with a slope of 0.002 are shown on plate 18. Maximum velocities in the inlet and outlet structures will be 25.1 and 26.2 feet per second, respectively. Computed velocities are indicated on plans and profiles of the concrete channel shown on plates 11, 12 and 13.

h. Analysis of bends. Of the numerous bends in the rectangular channel the shortest radius curve is between stations 34+05 and 36+89. Between these stations the channel turns a 97 degree arc on a centerline radius of 167 feet. A maximum superelevation at this bend of 2 feet was computed using the following formula. Therefore the maximum rise in water surface along the outside wall above the average design water surface is 1 foot.

$$S.E. = \frac{V^2 b}{R_c g}$$

where S.E. = Difference in elevation of water surface between the inside and outside walls

V = Velocity in feet per second

b = Channel width

R_c = Radius of curve in feet

g = Gravitational acceleration

i. Shock waves. An analysis was made to determine the probable height of shock or oblique standing waves that might occur in the concrete rectangular channel using the following basic equation from "Engineering Hydraulics," by Rouse, 1950, page 551.

$$Y/Y_1 = F_1^2 \sin^2\left(\beta_1 + \frac{\theta}{2}\right)$$

where Y_1 = Depth before wave

Y = Depth after wave

F_1 = Froude # before wave

β_1 = Wave deflection angle

θ = Wall deflection angle

The greatest shock wave potential will occur at the end of the inlet transition where flows enter the concrete rectangular channel. At this location $\theta = 9.1^\circ$, the Froude number $F_1 = 1.7$ and $\beta_1 = \sin^{-1} 1/F_1 = 36^\circ$, resulting in $Y/Y_1 = 1.2$. Since $Y_1 = 6.9$ feet a shock wave of 1.4 feet may occur resulting in a "Y" of 8.3 feet. This depth is still well below the design normal flow depth in the channel of 10.7 feet, therefore shock waves were not significant in determining wall heights.

j. Freeboard. Generally the concrete channel will be 13 feet deep providing a freeboard above the design water surface of 2.3 feet in straight sections of the channel. Selecting this freeboard was based on the following considerations:

(1) The top of the concrete walls will be below existing ground elevation for most of its length, therefore damages from short duration overtopping would be minor.

(2) Overtopping of a concrete wall, where it is above the ground, does not mean breeching of the protection as in the case of earth dikes.

(3) There are several bends in the concrete channel in addition to the one described in "h". The selected freeboard will provide protection for some superelevation in these lesser bends.

(4) In addition to the infrequency of the standard project flood, the peak flow at Danbury would occur for only about 2 hours.

One foot additional height will be provided on the left wall for superelevation at the bend upstream of Chestnut Street. The wall will be sloped uniformly upward from station 32+00 to 34+00. The one foot added height will then be maintained to the Chestnut Street bridge abutment, dropped to one-half foot between the bridges, and returned to normal at the downstream end of the railroad bridge abutment.

k. Discharge rating. A normal flow rating curve of depth above invert versus discharge for the 40-foot wide concrete rectangular channel is shown on plate 18. Computations were based on a Manning's "n" of 0.015 and a bottom slope of 0.002.

11. RIPRAPPED TRAPEZOIDAL CHANNEL

a. Description. The Still River flows will be conveyed in a riprapped trapezoidal channel from the outlet of the concrete rectangular channel, station 45+35 to the downstream limit of the project at station 72+60. The channel will have side slopes of 1 on 2 and the bottom width will diverge in the first 435 feet from a width of 55 to 80 feet. In a distance of 665 feet the bottom will transition from level to a triangular "V" shape with the center 3 feet lower than the outside edges. This "V"-shaped bottom was adopted to provide confinement of normal low flows. The channel will have an invert slope of 0.00117 from station 45+35 to station 52+00, 0.0010 from station 52+00 to station 70+00 and 0.0038 from station 70+00 to station 72+00. A general plan of the channel is shown on plates 14 and 15.

Initial soil explorations indicate that it may be necessary to flatten side slopes to 1 on 2.5. It has been determined that a channel with 1 on 2.5 side slopes and a 75-foot bottom width is comparable hydraulically and will be adopted if the change is found necessary. Final side slope selection will be presented in later design memoranda.

b. Water surface profiles. Water surface profiles were determined by backwater computations using the previously referenced computer program. Computations were started at Cross Street bridge, a natural hydraulic control 2,700 feet downstream of the Corps project. Backwater was computed from this control upstream through the State of Connecticut improved channel and then through the trapezoidal channel proposed by the Corps. Computations were made using a Manning's "n" of 0.035 and loss coefficients for expansion and contraction of 0.3 and 0.2, respectively. Water surface profiles for the proposed Corps channel are shown on plates 14 and 15.

c. Velocities. Average velocities in the trapezoidal channel for the design discharge of 6,900 cfs vary from 5.9 to 6.8 fps. Maximum velocities of 6.8 fps were computed for the section at station 45+50. The computed velocities are indicated on plates 14 and 15.

d. Freeboard design. The design depth of the channel and heights of dikes where necessary were established to provide a minimum of 3 feet of freeboard above the design water surface profile. Design heights of protection are illustrated on plates 14 and 15.

e. Riprap design

(1) General. The riverward slopes of dikes and the excavated trapezoidal channel will be protected with a layer of stone riprap. The design of riprap protection was based on the "tractive force" theory set forth in the draft report titled, "Criteria for Graded Stone Riprap Channel Protection," dated 20 April 1966.

(2) Design criteria. The stability of stone riprap against movement by tractive force is related to the equivalent diameter of the 50 percent by weight finer stones designated D_{50} minimum. Based on interpretation of information in the above referenced draft report, a graphical relationship was developed by this office between depth of flow "Y", friction slope "S" and permissible D_{50} minimum. This graph is shown on plate 21. For further discussion of the design criteria and development of the graphical solution reference is made to Design Memo No. 3, "Hydraulic Analysis and Riprap Design," dated April 1968 for the Local Protection Project, Derby, Connecticut.

(3) D_{50} minimums. D_{50} minimums were computed for the side slopes and bottoms of the channel for each reach having similar flow characteristics. The maximum local unit boundary shear in the section, which occurs at the toe of the side slope, was used in the design of the stone riprap for the entire slope. Depths of flow and friction slopes used in the analyses were the maximum derived from the backwater studies previously discussed. Representative cross sections used in the analyses and the computed D_{50} min's are shown on plate 20.

(4) Size and layer thickness of stone protection. The two classes of riprap to be specified for the project are described in table 1-7. Class I riprap will be used on all riverward side slopes of the channel and on the channel bottom upstream of station 49+00. Class II riprap will be used for the channel bottom downstream of station 49+00.

12. RIVER CROSSINGS

Presently there are four roadway and four railway crossings of the Still River within the limits of the project area. With the proposed project four of the railway bridges and two of the highway bridges, Chestnut and Casper Streets, will be replaced with new structures. The private roadway bridge at station 18+00 will be removed and Triangle Street bridge will not require modification.

The proposed modified plan, with the concrete rectangular channel, greatly improves the hydraulics of river crossings. All crossings of this channel will be clear span structures with adequate clearance between low chord and design water surface, thereby posing no hydraulic restriction.

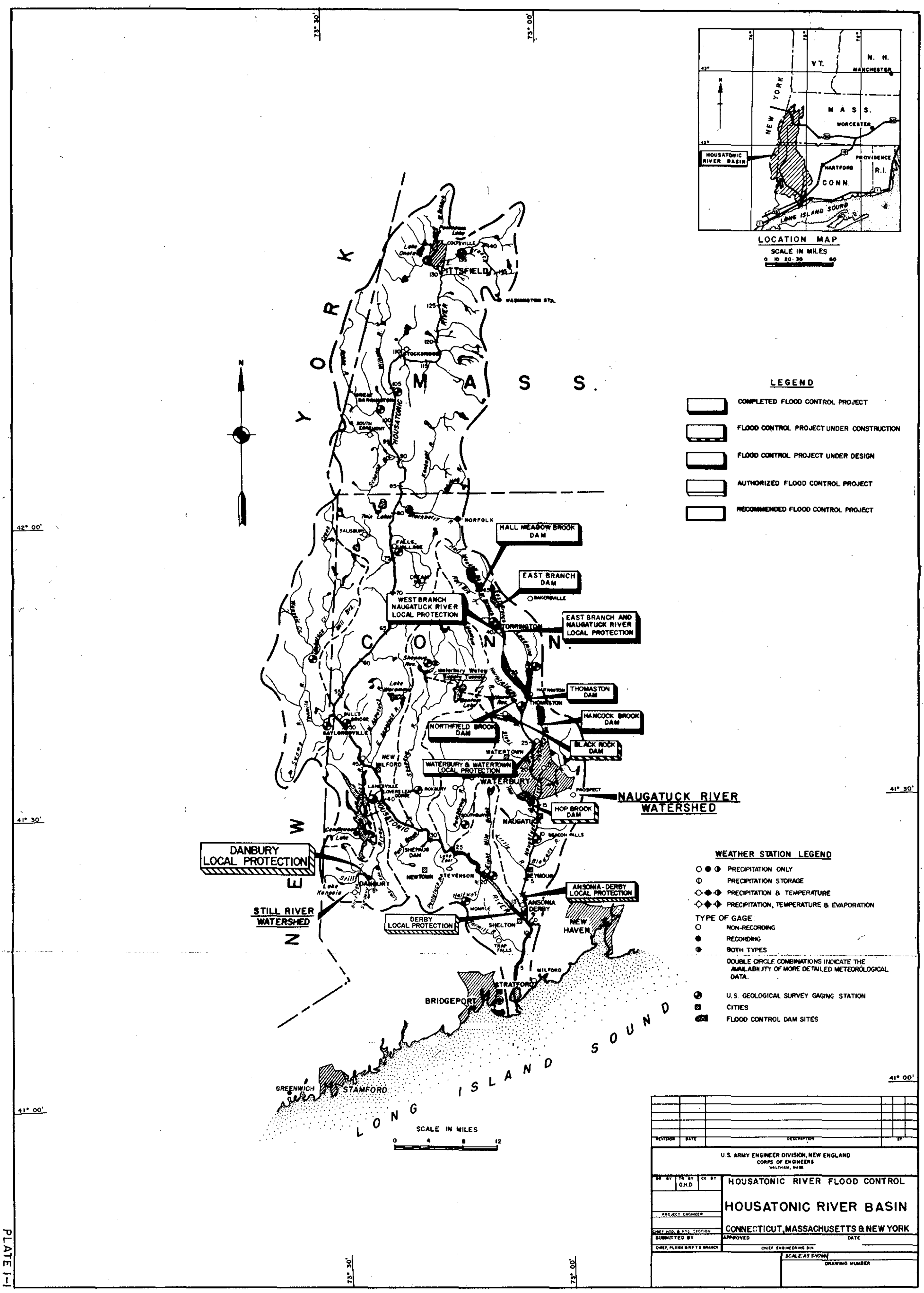
TABLE 1-7

CLASSES OF STONE RIPRAP

Class	Basic Layer Thickness (inches)	Stone Weight (lbs)	Percent by Weight (SSD) Finer	D50 Min. (feet)
I	12*	90 max.	100	0.55
		Between 15-25	50	
		Less than 10	15	
		2 min.	0	
II	9	40 max.	100	0.35
		Between 4-10	50	
		0.5 min.	0	

* To be increased to 24 inches on channel bottom for a distance of 50 feet downstream of stilling basin

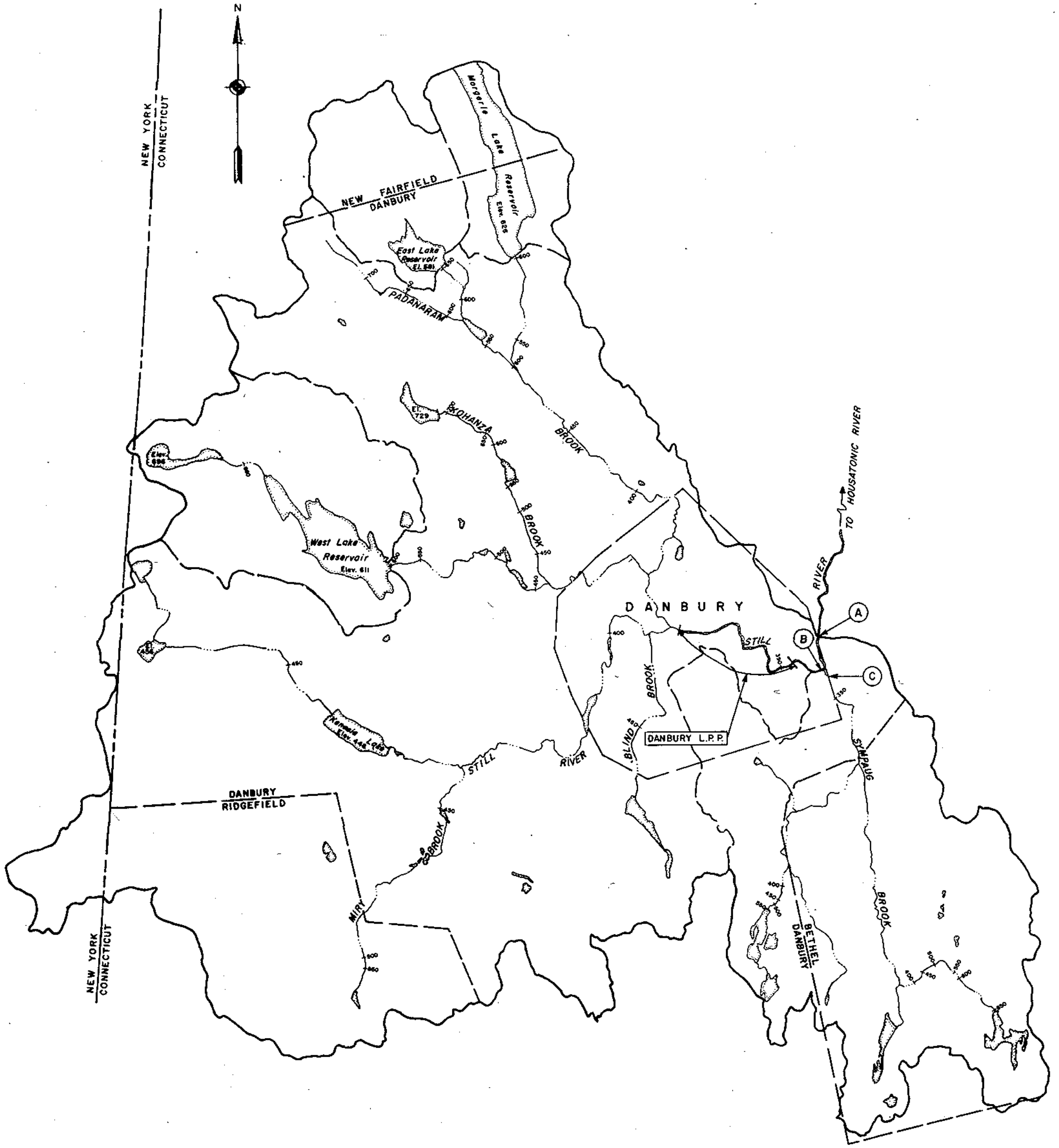
Bedding Material - A minimum of 12 inches of bank run gravel will be used for bedding throughout



LOCATION MAP
SCALE IN MILES
VT.
N. H.
MANCHESTER
NEW YORK
MASS.
WORCESTER
PROVIDENCE
R.I.
HARTFORD
CONN.
LONG ISLAND SOUND
HOUSATONIC RIVER BASIN
LEGEND
COMPLETED FLOOD CONTROL PROJECT
FLOOD CONTROL PROJECT UNDER CONSTRUCTION
FLOOD CONTROL PROJECT UNDER DESIGN
AUTHORIZED FLOOD CONTROL PROJECT
RECOMMENDED FLOOD CONTROL PROJECT
NEW YORK
MASS.
CONN.
PITTSFIELD
HALL MEADOW BROOK DAM
EAST BRANCH DAM
WEST BRANCH NAUGATUCK RIVER LOCAL PROTECTION
EAST BRANCH AND NAUGATUCK RIVER LOCAL PROTECTION
TORRINGTON
THOMASTON DAM
HANCOCK BROOK DAM
NORTHFIELD BROOK DAM
BLACK ROCK DAM
WATERBURY & WATERTOWN LOCAL PROTECTION
WATERBURY
NAUGATUCK RIVER WATERSHED
HOP BROOK DAM
DANBURY LOCAL PROTECTION
STILL RIVER WATERSHED
DANBURY
ANSONIA-DERBY LOCAL PROTECTION
DERBY LOCAL PROTECTION
NEW HAVEN
BRIDGEPORT
STRATFORD
STAMFORD
GREENWICH
LONG ISLAND SOUND
WEATHER STATION LEGEND
PRECIPITATION ONLY
PRECIPITATION STORAGE
PRECIPITATION & TEMPERATURE
PRECIPITATION, TEMPERATURE & EVAPORATION
TYPE OF GAGE
NON-RECORDING
RECORDING
BOTH TYPES
DOUBLE CIRCLE COMBINATIONS INDICATE THE AVAILABILITY OF MORE DETAILED METEOROLOGICAL DATA.
U.S. GEOLOGICAL SURVEY GAGING STATION
CITIES
FLOOD CONTROL DAM SITES
SCALE IN MILES
0 4 8 12
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
HOUSATONIC RIVER BASIN
CONNECTICUT, MASSACHUSETTS & NEW YORK
SCALE: AS SHOWN

PLATE I-I

CORPS OF ENGINEERS U. S. ARMY



POINT	DESCRIPTION OF BASIN	DRAINAGE AREA
A	STILL RIVER BASIN AT CROSS ST. BRIDGE	38.3 SQ. MI.
B	STILL RIVER BASIN AT SYMPAUG BROOK	31.0 SQ. MI.
C	SYMPAUG BROOK BASIN AT STILL RIVER	7.3 SQ. MI.

LEGEND

Elevation in feet M.S.L.

GRAPHIC SCALE

1" = 2000' 2000 0 2000 4000 6000

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED: CHIEF, SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

REVIEWED: PROJECT ENGINEER

APPROVAL RECOMMENDED: CHIEF BRANCH

HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

WATERSHED MAP

STILL RIVER CONNECTICUT

APPROVED DATE

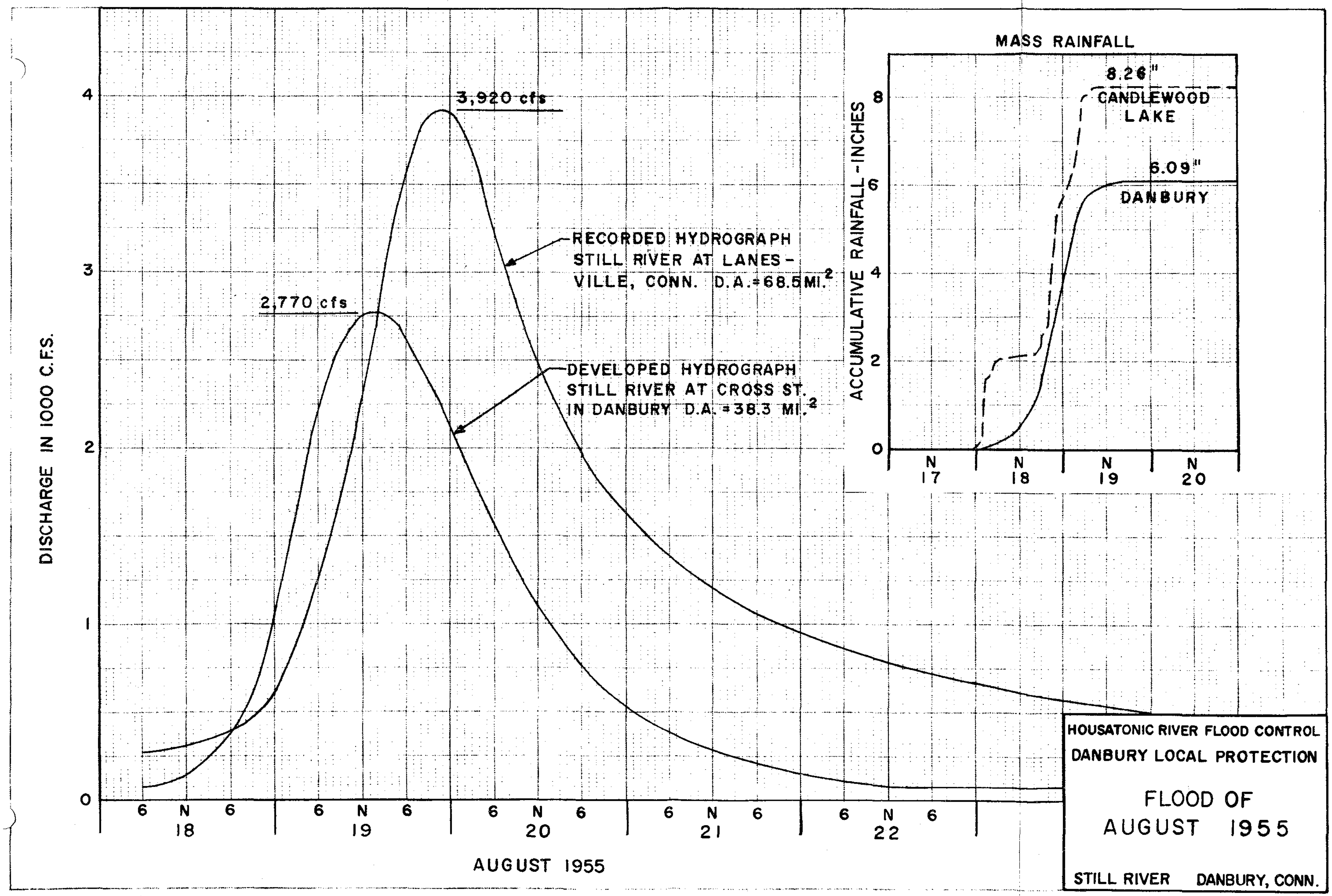
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.

DRAWING NUMBER

SHEET

PLATE I-2



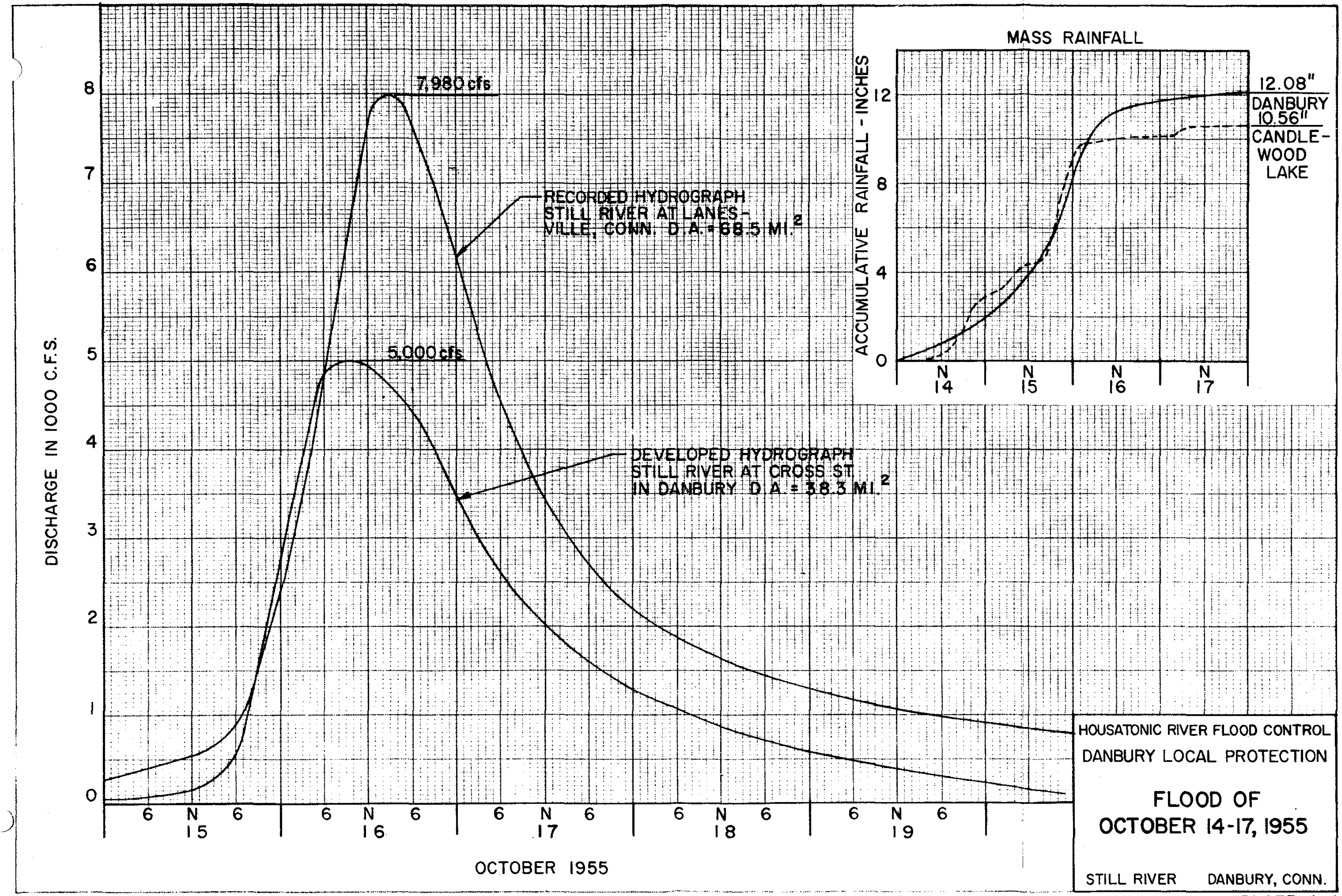
HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

FLOOD OF
AUGUST 1955

STILL RIVER DANBURY, CONN.

PLATE I-3



HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

FLOOD OF OCTOBER 14-17, 1955

STILL RIVER DANBURY, CONN.

PLATE I-4

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

UNIT HYDROGRAPH BASIC DATA SHEET

(7) STREAM AND STATION Still River, Danbury, Connecticut LAT. ______ LONG. ______

(8) DATE OF STORM 17-19 August 1955 (9) OFFICE New England Division

(10) DRAINAGE AREA 38.3 SQ.MI. (11) L 9.08 MI. (12) L_{ca} 4.74 MI. (13) $(LL_{ca})^{0.3}$ 3.1

(14) AVERAGE RAINFALL 6.09 IN. (15) t_R 12 HRS. (16) DIRECT RUNOFF 3.6 IN.

(17) Q_{pR} 768 CFS. (18) q_{pR} 20.1 CFS/SQ.MI. (19) Q_p 805 CFS. (20) t_{pR} 14.5 HRS.

(21) t_p 10.5 HRS. (22) t_v ______ HRS. (23) C_{tR} 4.68 (24) C_p640 291 W_{50} ______ HRS. W_{75} ______ HRS.

TIME DAY/HR. (25)	OBSERVED DISCHARGE (~~1000~~ CFS) (26)	ESTIMATED BASE FLOW (~~1000~~ CFS) (27)	DIRECT RUNOFF (~~1000~~ CFS) (28)	OBSERVED 12 HR UNIT HYDROGRAPH (~~1000~~ CFS) (29)	ADJUSTED 3 HR UNIT HYDROGRAPH (~~1000~~ CFS) (30)	REPRODUCED STORM HYDROGRAPH (~~1000~~ CFS) (31)	(32)	(33)
18 6p	75	75	0	0	0			
9p	350	75	275	76	280			
12m	1,000	75	925	256	600			
19 3a	1,655	75	1,580	438	750			
6a	2,200	75	2,125	589	805			
9a	2,570	75	2,495	691	785			
12n	2,760	75	2,685	744	748			
3p	2,755	75	2,680	743	692			
6p	2,630	75	2,555	708	600			
9p	2,400	75	2,325	644	528			
12m	2,125	75	2,050	568	450			
20 3a	1,840	75	1,765	489	380			
6a	1,570	75	1,495	414	320			
9a	1,325	75	1,250	347	265			
12n	1,120	75	1,045	290	215			
3p	930	75	855	237	180			
6p	765	75	690	192	150			
9p	635	75	560	155	125			
12m	530	75	455	126	100			
21 3a	450	75	375	104	80			
6a	385	75	310	86	62			
9a	330	75	255	71	47			
12n	280	75	205	57	35			
3p	250	75	175	49	28			
6p	220	75	145	40	20			
9p	180	75	105	29	10			
12m	155	75	80	22	5			
22 3a	130	75	55	15	2			
6a	105	75	30	9	0			
9a	90	75	15	4				
12n	75	75	0	0				

DATE COMPUTED BY

ENG FORM 1 NOV 49 1823 (EM 1110-2-1405)

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

UNIT HYDROGRAPH BASIC DATA SHEET

(7) STREAM AND STATION Still River, Danbury, Connecticut LAT. ______ LONG. ______

(8) DATE OF STORM 14-17 October 1955 (9) OFFICE New England Division

(10) DRAINAGE AREA 38.3 SQ.MI. (11) L 9.08 MI. (12) L_{ca} 4.74 MI. (13) $(LL_{ca})^{0.3}$ 3.1

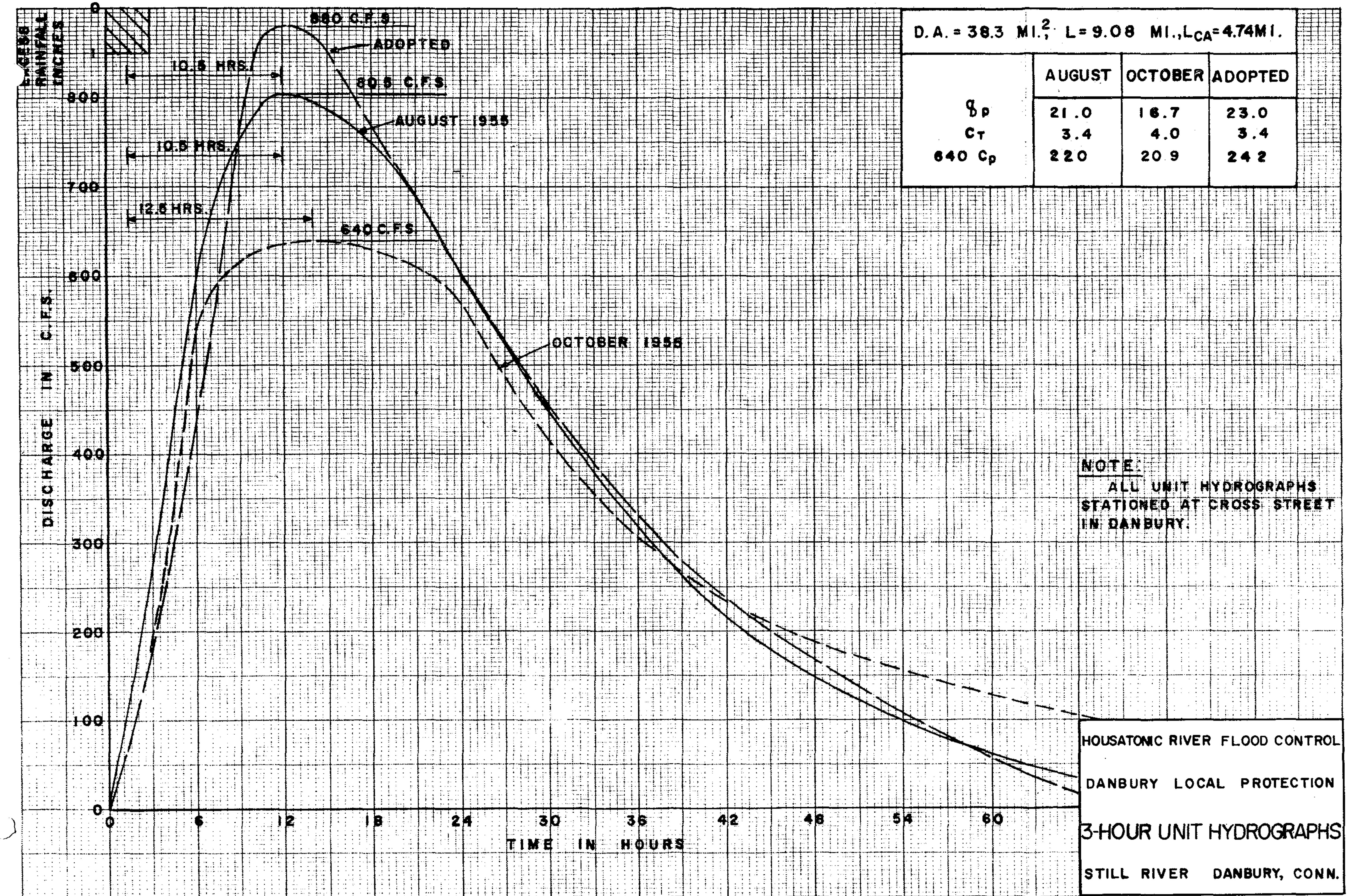
(14) AVERAGE RAINFALL 12.08 IN. (15) t_R 12 HRS. (16) DIRECT RUNOFF 7.73 IN.

(17) Q_{pR} 640 CFS. (18) q_{pR} 16.7 CFS/SQ.MI. (19) Q_p 640 CFS. (20) t_{pR} 13.0 HRS.

(21) t_p 12.5 HRS. (22) t_v ______ HRS. (23) C_{tR} 4.2 (24) C_p640 217 W_{50} ______ HRS. W_{75} ______ HRS.

TIME DAY/HR. (25)	OBSERVED DISCHARGE (~~1000~~ CFS) (26)	ESTIMATED BASE FLOW (~~1000~~ CFS) (27)	DIRECT RUNOFF (~~1000~~ CFS) (28)	OBSERVED 12 HR UNIT HYDROGRAPH (~~1000~~ CFS) (29)	ADJUSTED 3 HR UNIT HYDROGRAPH (~~1000~~ CFS) (30)	REPRODUCED STORM HYDROGRAPH (~~1000~~ CFS) (31)	(32)	(33)
15 3p	50	50	0	0	0			
6p	430	50	380	49	180			
9p	1,350	50	1,300	168	540			
12m	2,800	50	2,750	356	615			
16 3a	4,250	50	4,200	543	636			
6a	4,830	50	4,780	618	640			
9a	5,000	50	4,950	640	631			
12n	4,940	50	4,890	632	611			
3p	4,740	50	4,690	607	570			
6p	4,400	50	4,350	563	490			
9p	3,960	50	3,910	506	415			
12m	3,420	50	3,370	436	356			
17 3a	2,975	50	2,925	378	309			
6a	2,610	50	2,560	331	267			
9a	2,300	50	2,250	291	235			
12n	2,040	50	1,990	257	210			
3p	1,810	50	1,760	228	190			
6p	1,600	50	1,550	201	172			
9p	1,420	50	1,370	177	156			
12m	1,270	50	1,220	158	145			
18 3a	1,160	50	1,110	144	130			
6a	1,050	50	1,000	129	118			
9a	960	50	910	118	105			
12n	875	50	825	107	90			
3p	800	50	750	97	82			
6p	730	50	680	88	71			
9p	670	50	620	80	60			
12m	600	50	550	71	48			
19 3a	530	50	480	62	38			
6a	470	50	420	54	30			
9a	410	50	360	47	20			
12n	360	50	310	40	12			
3p	320	50	270	35	7			
6p	280	50	230	30	5			
9p	240	50	190	25	2			
12m	200	50	150	19	0			
20 3a	175	50	125	16				
6a	145	50	95	12				
9a	120	50	70	9				
12n	90	50	40	5				

DATE COMPUTED BY



D.A. = 38.3 MI.^{2}; L = 9.08 MI., L_{CA} = 4.74 MI.

	AUGUST	OCTOBER	ADOPTED
q_p	21.0	16.7	23.0
C_T	3.4	4.0	3.4
640 C_p	220	209	242

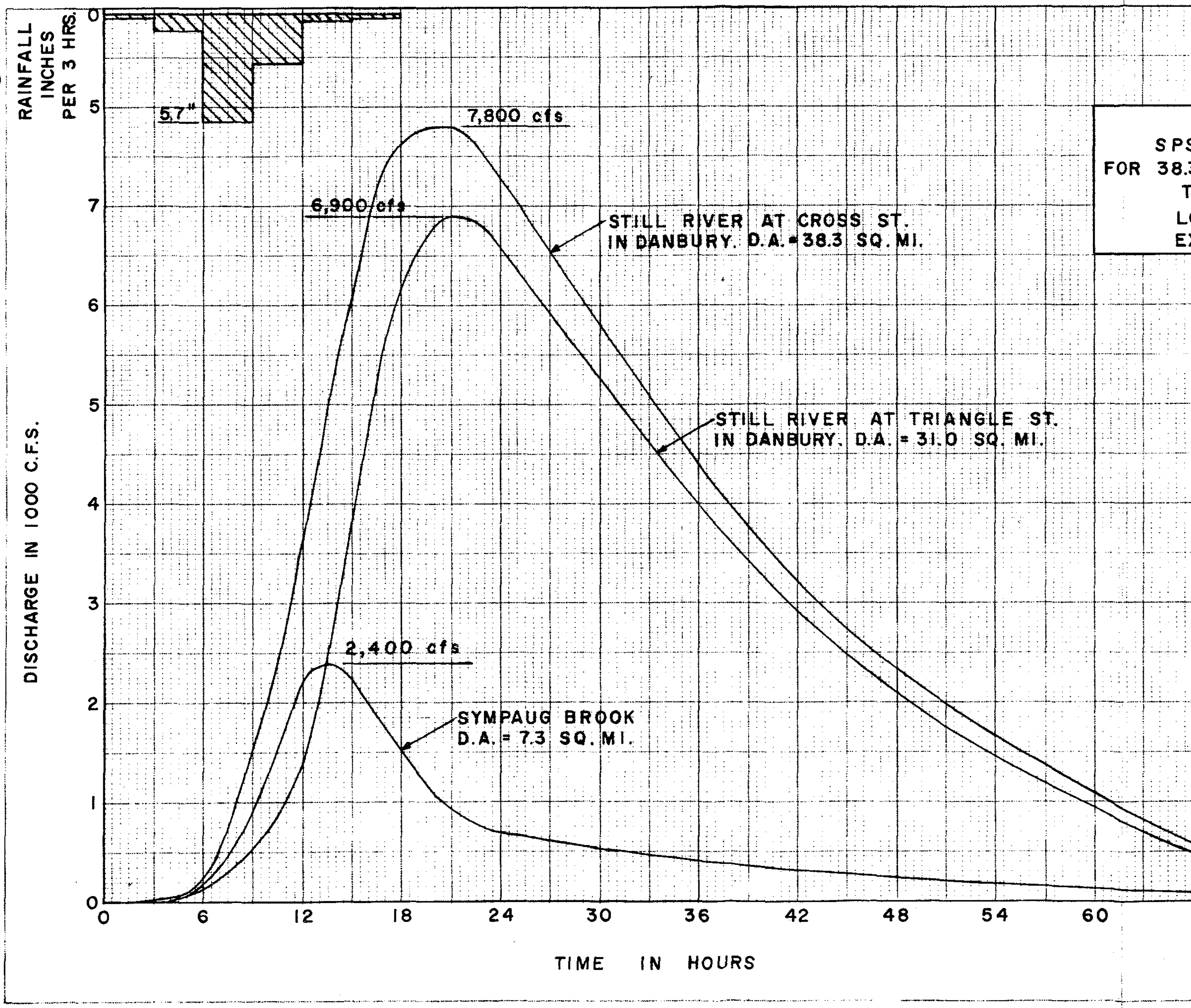
HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

3-HOUR UNIT HYDROGRAPHS

STILL RIVER DANBURY, CONN.

PLATE I-7



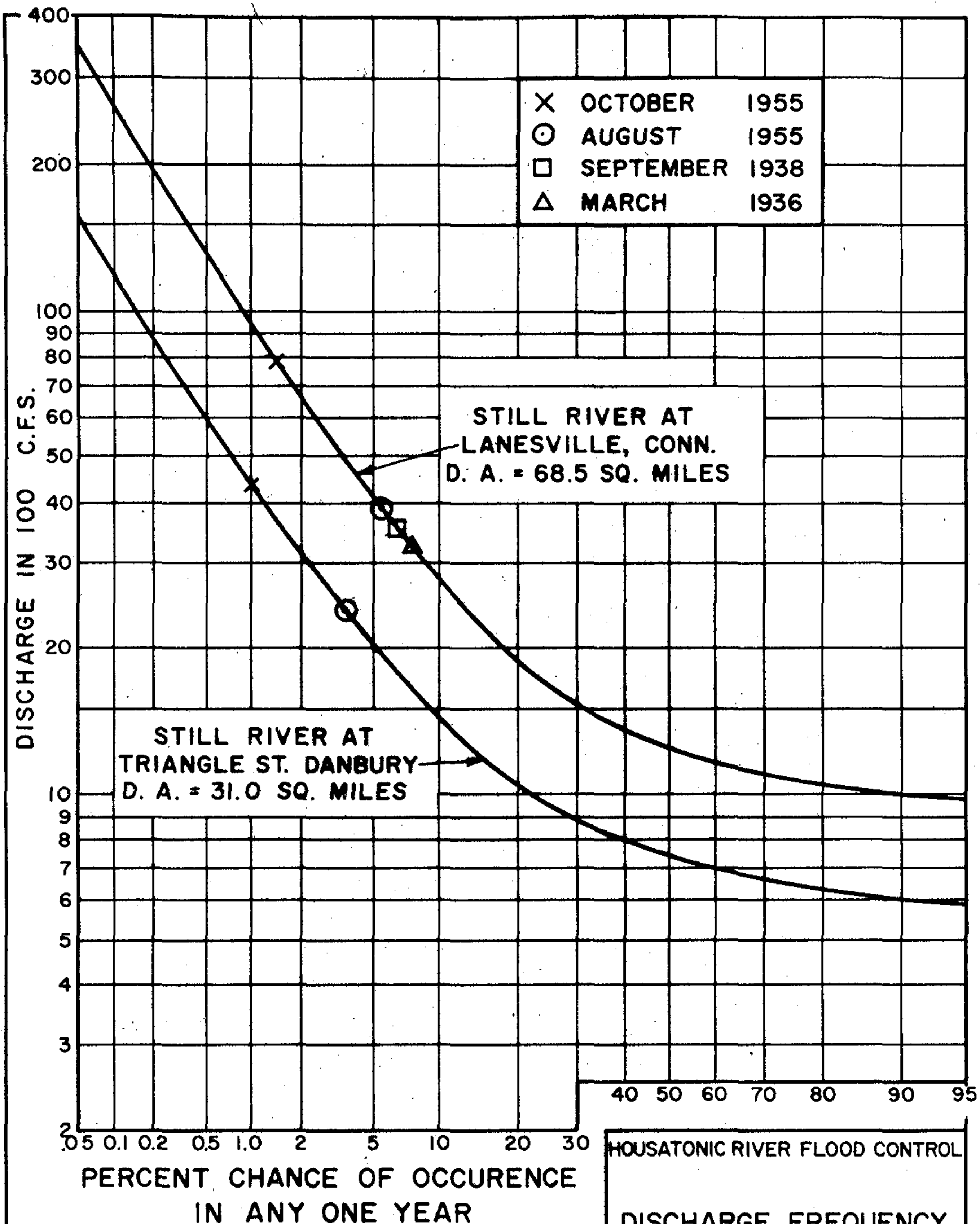
HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

STANDARD PROJECT FLOOD

STILL RIVER DANBURY, CONN.

PLATE 1-8



HOUSATONIC RIVER FLOOD CONTROL

DISCHARGE FREQUENCY CURVES

NEW ENGLAND DIVISION
WALTHAM, MASS.

PLATE I-9

CORPS OF ENGINEERS U. S. ARMY

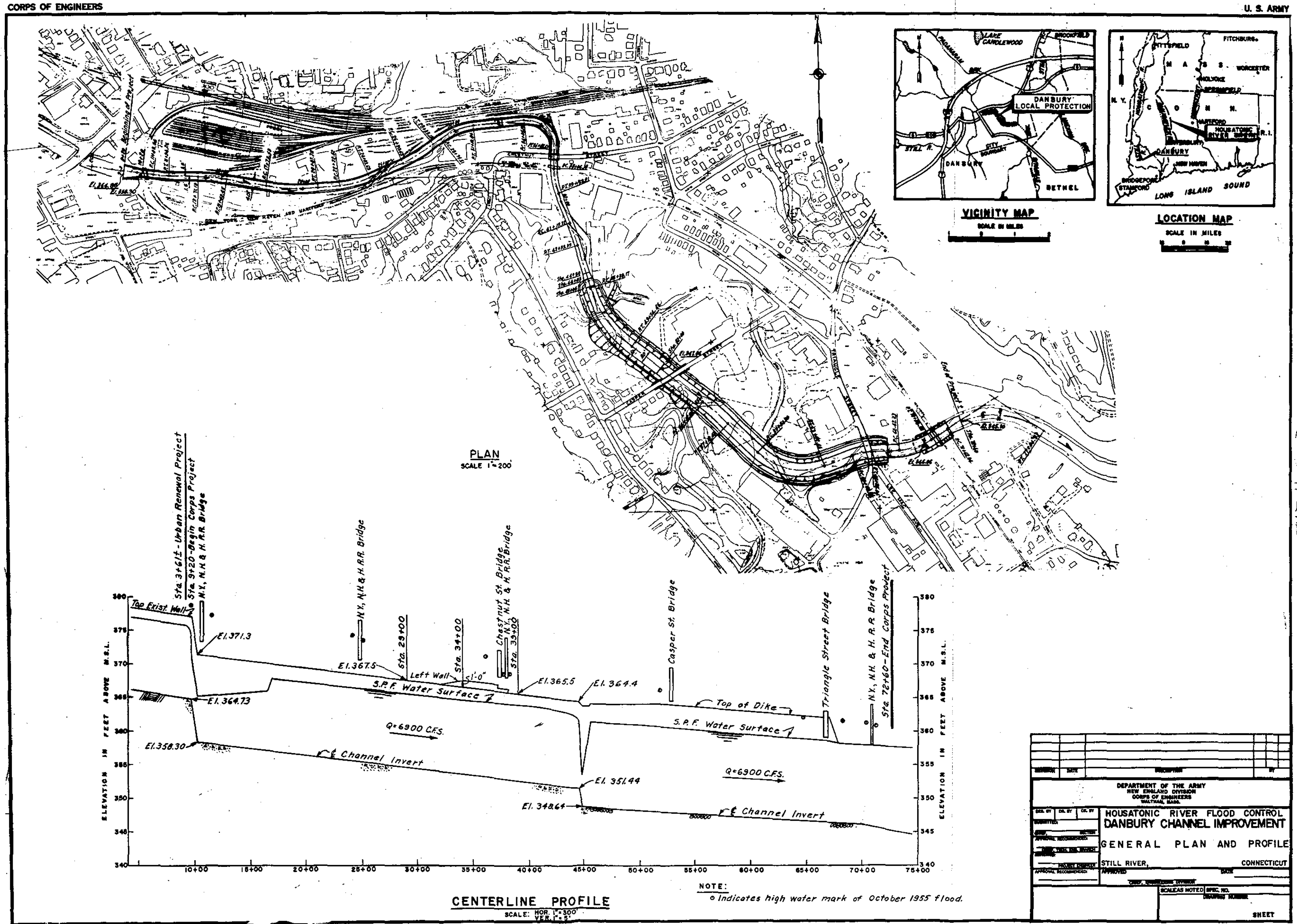
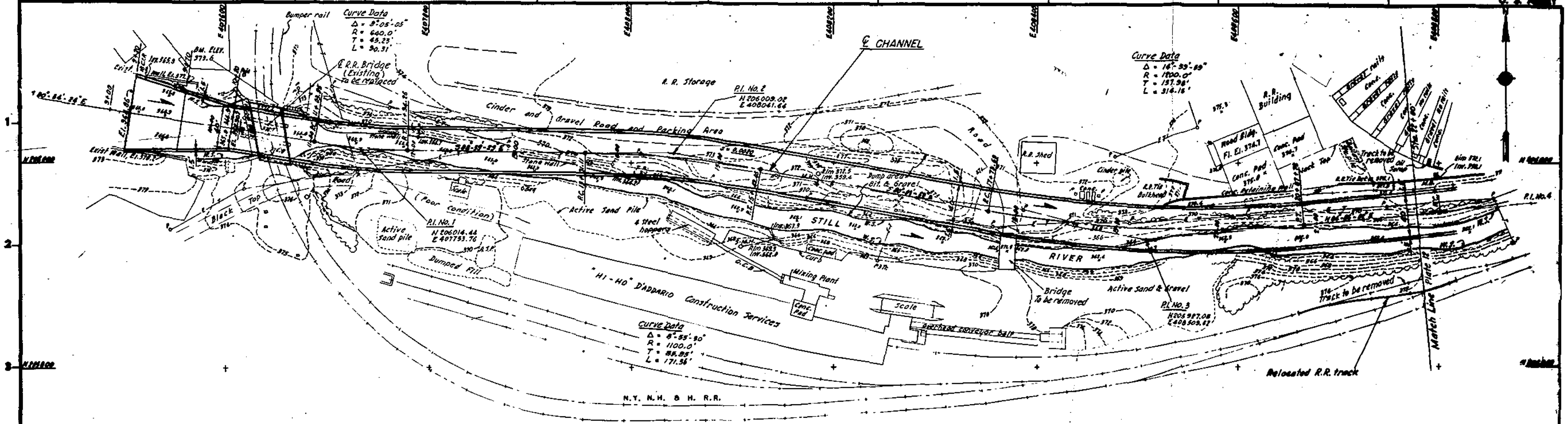
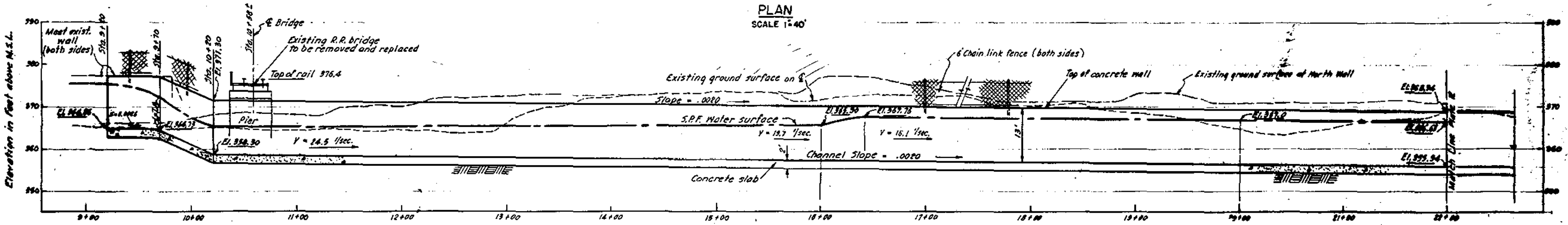


PLATE I-10

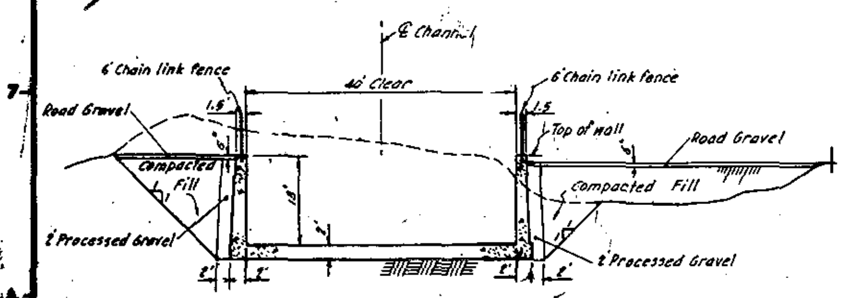
CORPS OF ENGINEERS U. S. ARMY



PLAN
SCALE 1"=40'



PROFILE ON ℄ OF CHANNEL
SCALE HOR. 1"=40'
VERT. 1"=10'



TYPICAL SECTION
SCALE 1"=10'

GRAPHIC SCALES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
DANBURY CHANNEL IMPROVEMENT
PLAN AND PROFILE NO. 1
STA. 9+20 TO STA. 22+00
STILL RIVER, CONNECTICUT

PLATE 1-11

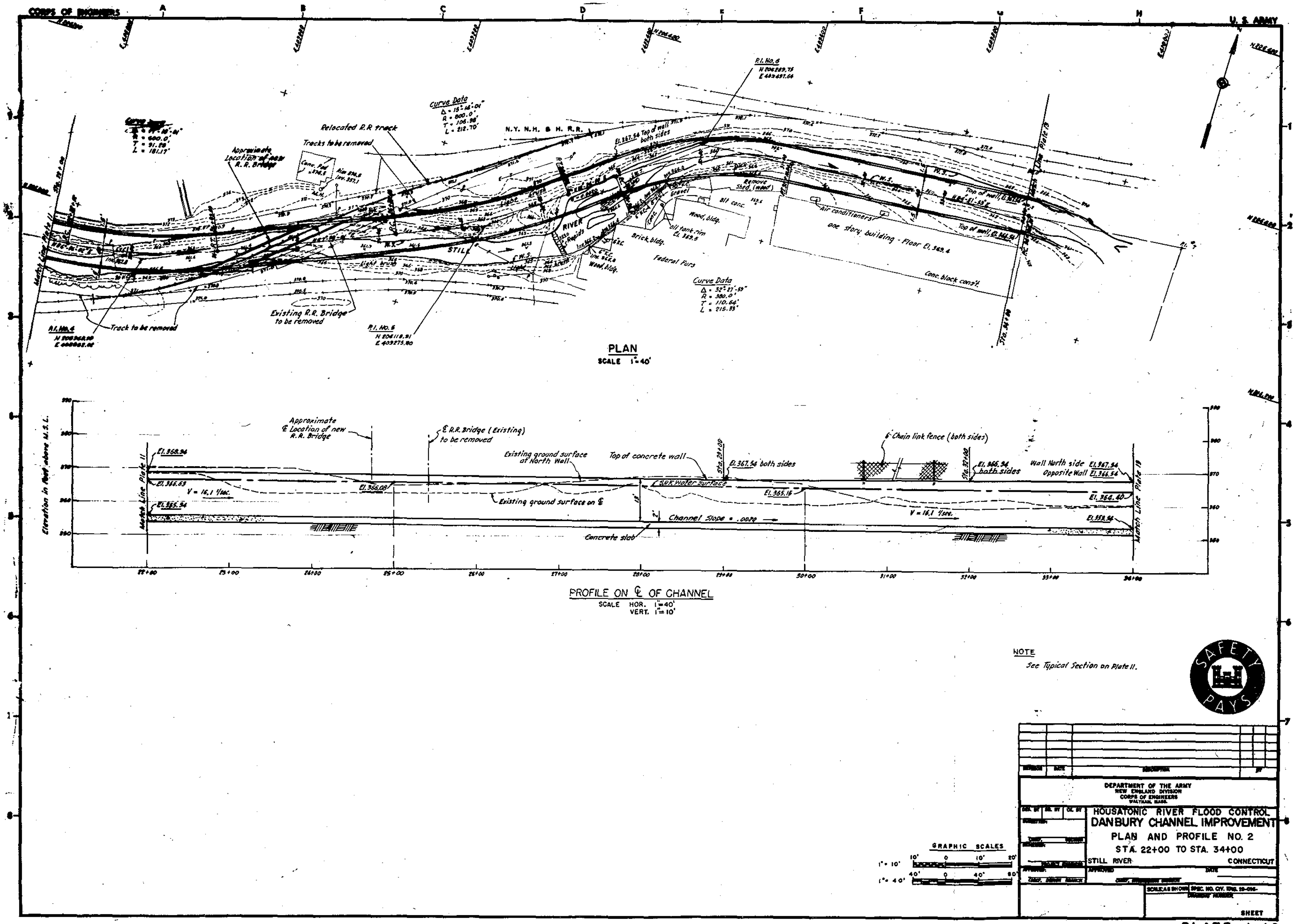
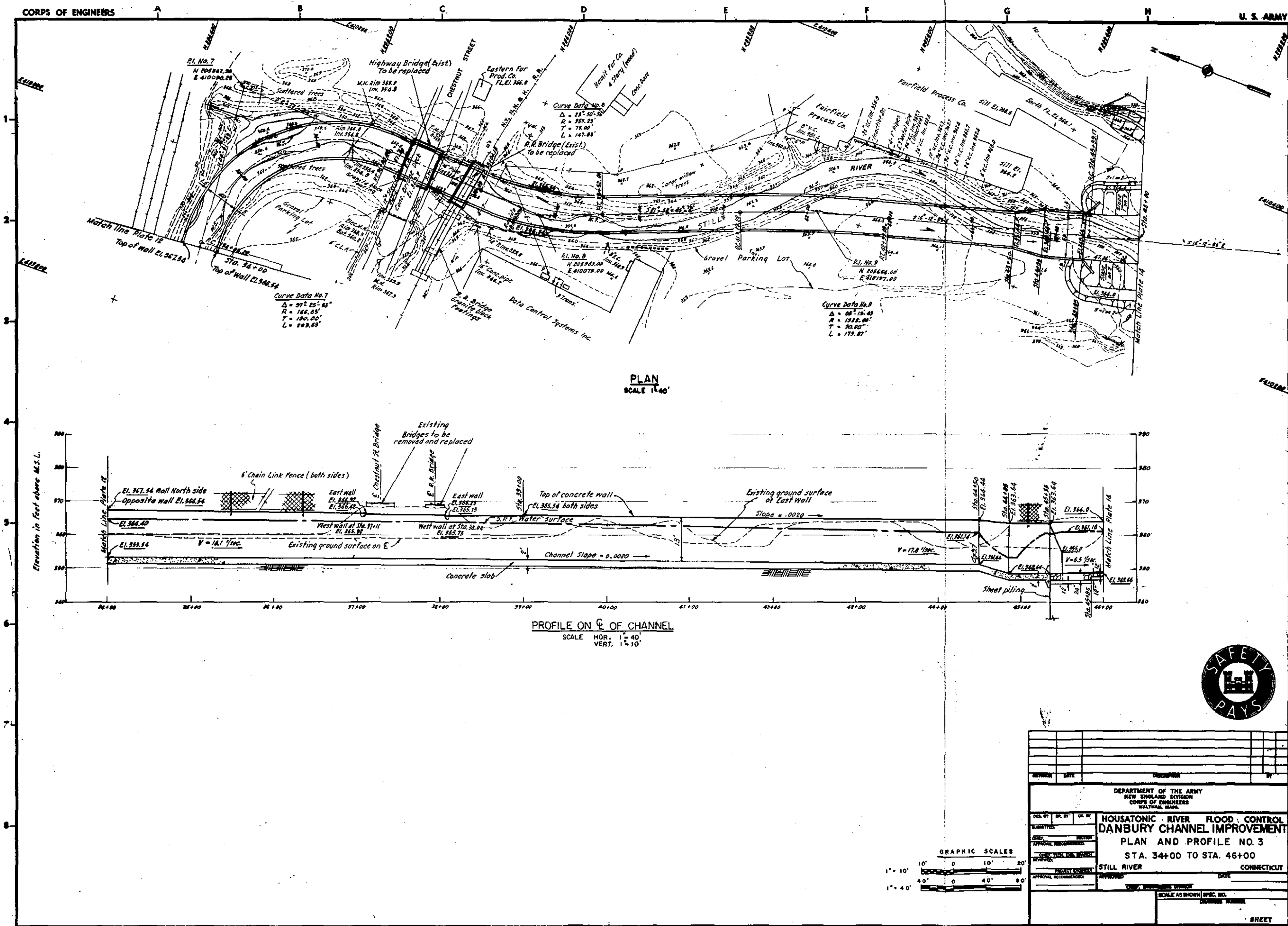

CORPS OF ENGINEERS
U. S. ARMY
PLAN
SCALE 1"=40'
PROFILE ON ℄ OF CHANNEL
SCALE HOR. 1"=40'
VERT. 1"=10'
Relocated R.R. track
Tracks to be removed
Approximate Location of new R.R. Bridge
Existing R.R. Bridge to be removed
Track to be removed
N.Y. N.H. & H. R.R.
Top of wall both sides
Remove Shed (wood)
Air conditioners
one story building - Floor El. 369.4
Conc. block const.
Federal Furs
Brick bldg.
Wood bldg.
STILL RIVER
Curve Data
P.I. No. 4
P.I. No. 5
P.I. No. 6
Match Line Plate 11
Match Line Plate 13
Elevation in Feet above M.S.L.
Approximate ℄ Location of new R.R. Bridge
℄ R.R. Bridge (Existing) to be removed
Existing ground surface at North Wall
Top of concrete wall
El. 367.54 both sides
Chain link fence (both sides)
Wall North side El. 367.54
Opposite Wall El. 366.54
S.P.F. water surface
Existing ground surface on ℄
Channel Slope = .0024
Concrete slab
V = 16.1 ft/sec.
22+00
23+00
24+00
25+00
26+00
27+00
28+00
29+00
30+00
31+00
32+00
33+00
34+00
NOTE
See Typical Section on Plate 11.
SAFETY PAYS
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
DANBURY CHANNEL IMPROVEMENT
PLAN AND PROFILE NO. 2
STA. 22+00 TO STA. 34+00
STILL RIVER
CONNECTICUT
SHEET

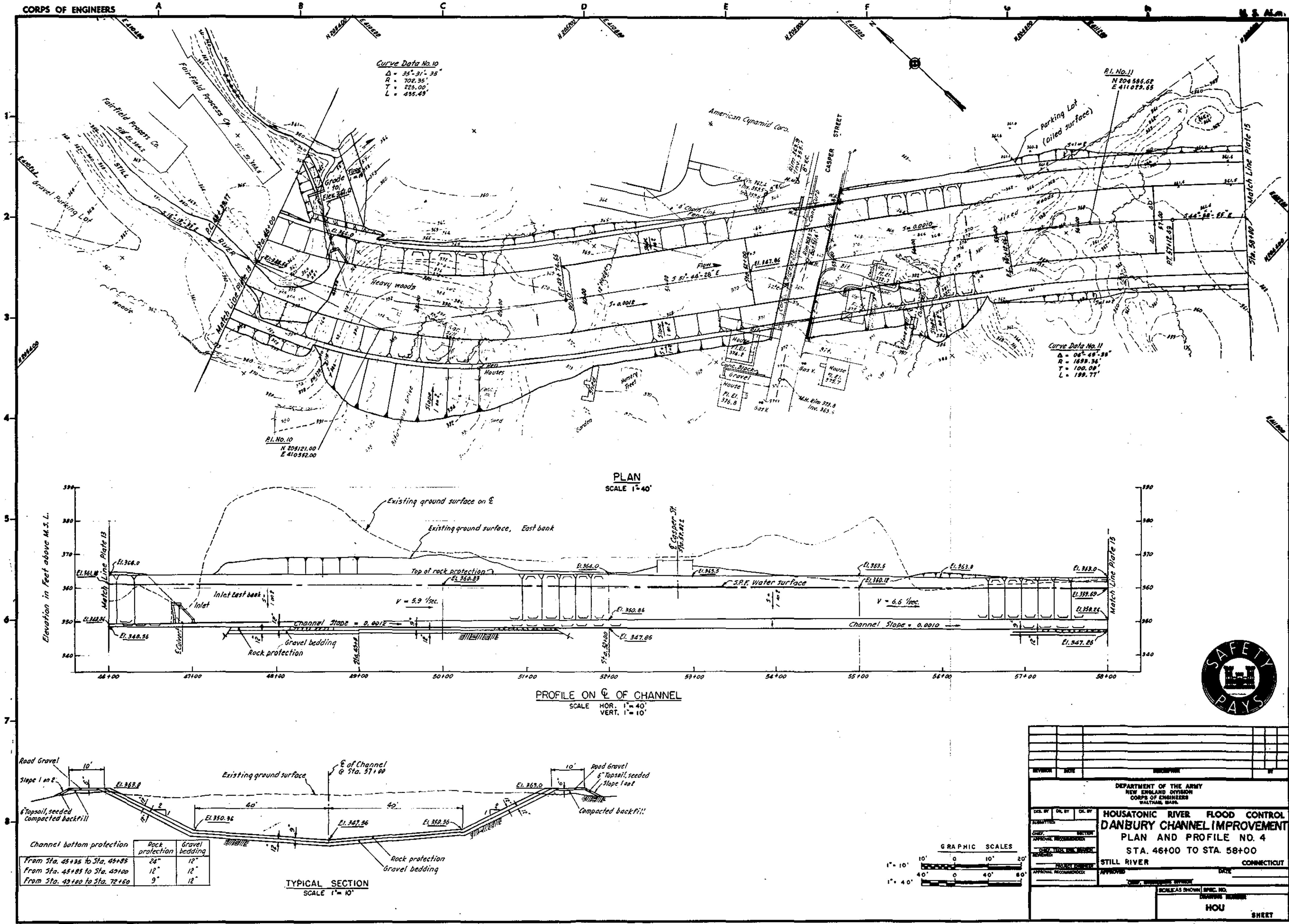
PLATE 1-12



CORPS OF ENGINEERS
U. S. ARMY
Highway Bridge (Exist.) To be replaced
CHESTNUT STREET
Eastern Fur Prod. Co.
R.R. Bridge (Exist.) To be replaced
Scattered trees
Gravel Parking Lot
Match line Plate 12
Top of Wall El. 367.54
Sta. 34+00
Top of Wall El. 366.54
Curve Data No. 7
Curve Data No. 8
Curve Data No. 9
P.I. No. 7
P.I. No. 8
P.I. No. 9
R.R. Bridge Granite Block Footings
Data Control Systems Inc.
Fairfield Process Co.
STILL RIVER
Large willow trees
Gravel Parking Lot
Match Line Plate 14
PLAN
SCALE 1"=40'
Elevation in Feet above M.S.L.
Existing Bridges to be removed and replaced
6' Chain Link Fence (both sides)
El. 367.54 Wall North side
Opposite Wall El. 366.54
East wall
West wall at Sta. 37+11
West wall at Sta. 38.06
Top of concrete wall
El. 365.54 both sides
S.P.F. Water surface
Existing ground surface on ℄
Existing ground surface of East Wall
Slope = .0020
Channel Slope = 0.0020
Concrete slab
V = 18.1 '/sec.
V = 17.8 '/sec.
V = 6.5 '/sec.
Sheet piling
PROFILE ON ℄ OF CHANNEL
SCALE HOR. 1"=40' VERT. 1"=10'
SAFETY PAYS
GRAPHIC SCALES
1" = 10'
1" = 40'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
DANBURY CHANNEL IMPROVEMENT
PLAN AND PROFILE NO. 3
STA. 34+00 TO STA. 46+00
STILL RIVER
CONNECTICUT

PLATE 1-13

CORPS OF ENGINEERS



Channel bottom protection	Rock protection	Gravel bedding
From Sta. 45+35 to Sta. 45+85	24"	12"
From Sta. 45+85 to Sta. 49+00	12"	12"
From Sta. 49+00 to Sta. 72+60	9"	12"

PLATE 1-14

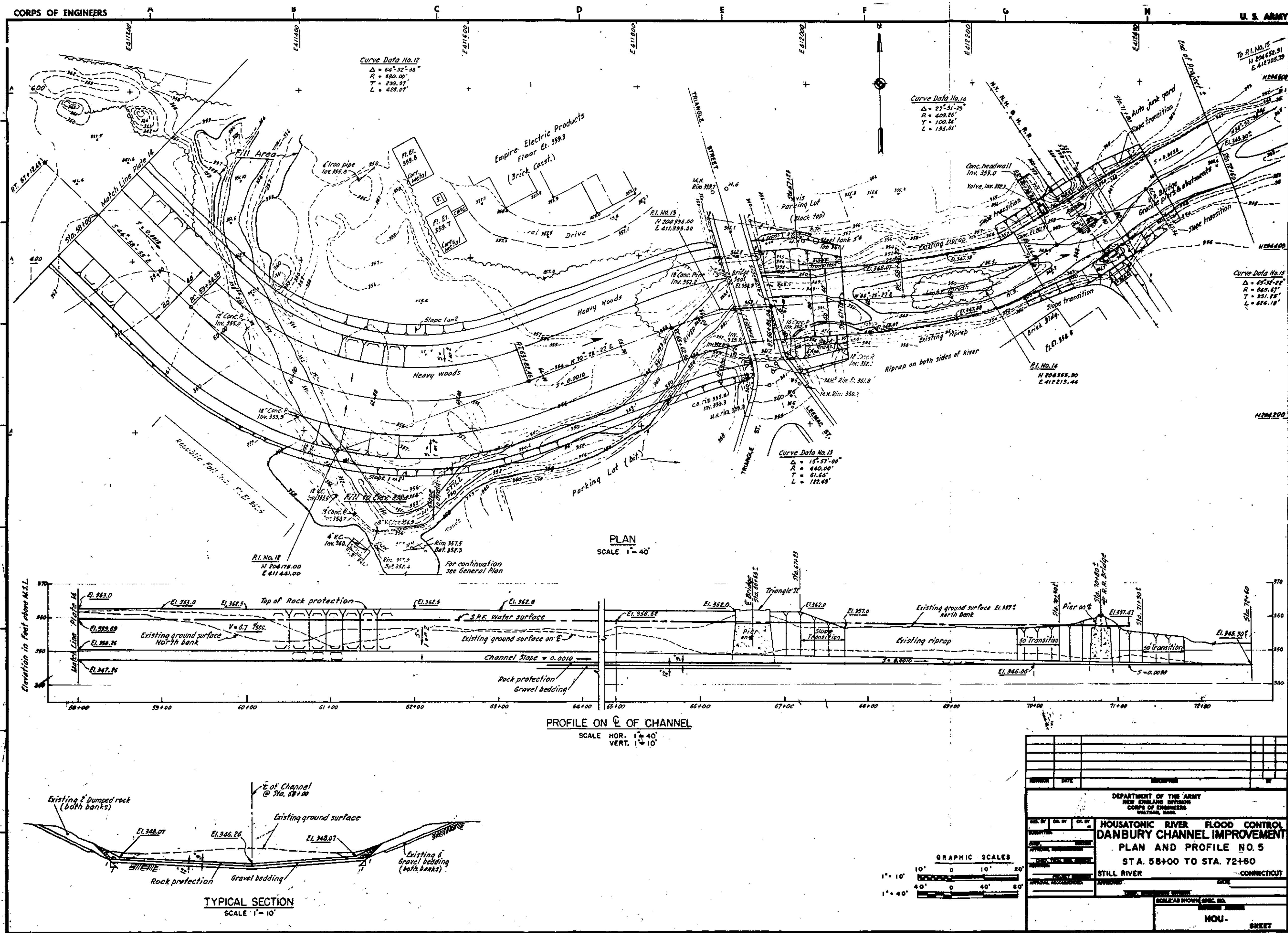
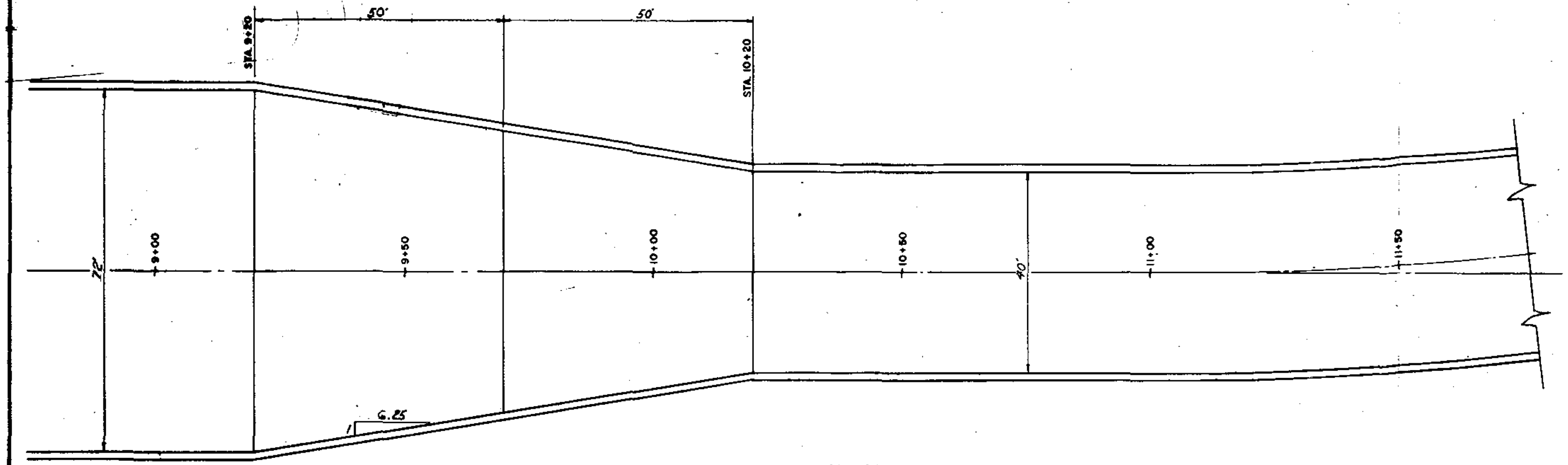
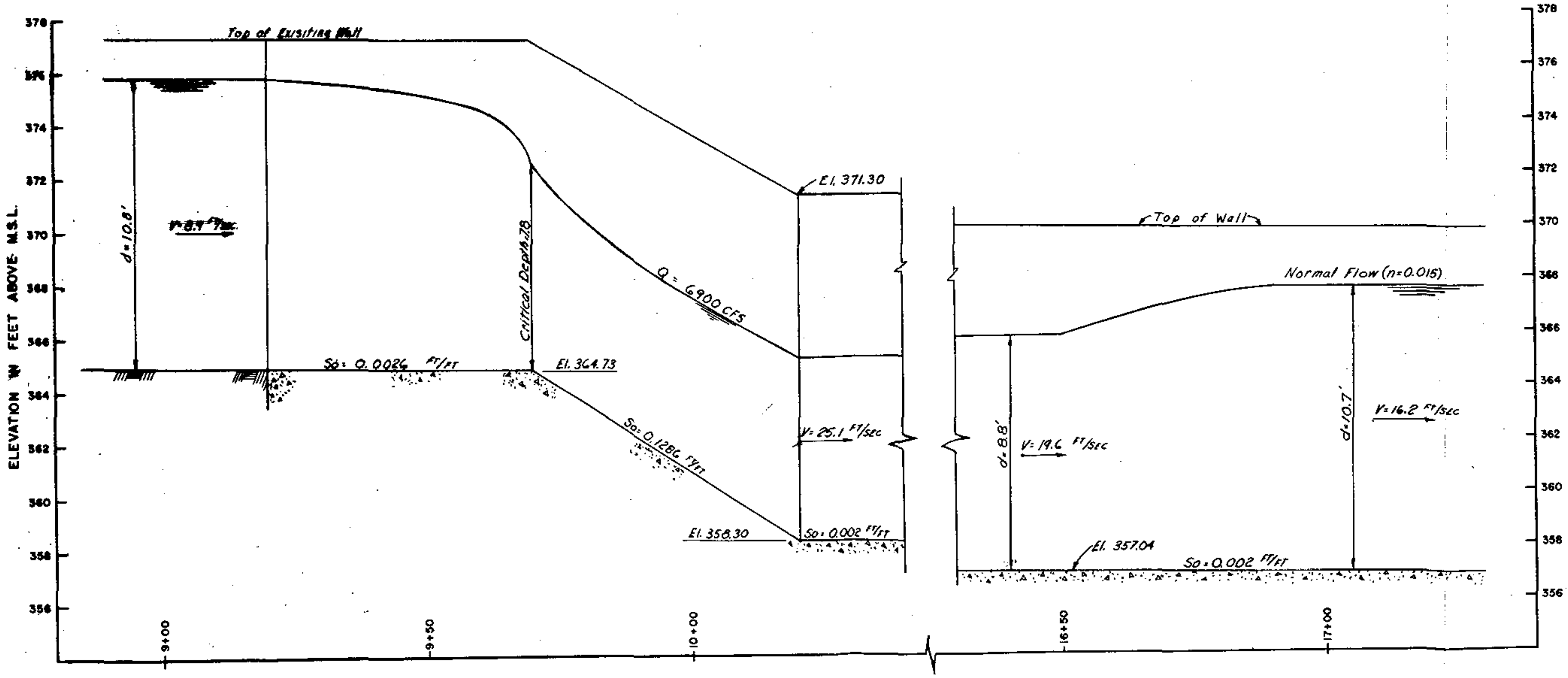

CORPS OF ENGINEERS
U. S. ARMY
Curve Data No. 12
Curve Data No. 13
Curve Data No. 14
Curve Data No. 15
Empire Electric Products Floor El. 359.3 (Brick Const.)
Fill Area
Heavy Woods
Heavy woods
Parking Lot (bit.)
Parking Lot (Black top)
Existing riprap
Riprap on both sides of River
Slope transition
Auto junk yard
TRIANGLE STREET
TRIANGLE ST.
LEEMAC ST.
N.Y. N.H. & H. R.R.
Match Line Plate 14
End of Project
PLAN
SCALE 1" = 40'
For continuation see General Plan
Elevation in Feet above M.S.L.
Top of Rock protection
S.P.F. Water surface
Existing ground surface North bank
Existing ground surface on ℄
Channel Slope = 0.0010
Rock protection
Gravel bedding
Existing riprap
50' Transition
Slope Transition
Pier on ℄
PROFILE ON ℄ OF CHANNEL
SCALE HOR. 1" = 40'
VERT. 1" = 10'
Existing & Dumped rock (both banks)
℄ of Channel @ Sta. 58+00
Existing ground surface
Existing 6" Gravel bedding (both banks)
Rock protection
Gravel bedding
TYPICAL SECTION
SCALE 1" = 10'
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
DANBURY CHANNEL IMPROVEMENT
PLAN AND PROFILE NO. 5
STA. 58+00 TO STA. 72+60
STILL RIVER
CONNECTICUT
HOU-

PLATE I-15

CORPS OF ENGINEERS | U.S. ARMY



PLAN



CENTERLINE PROFILE

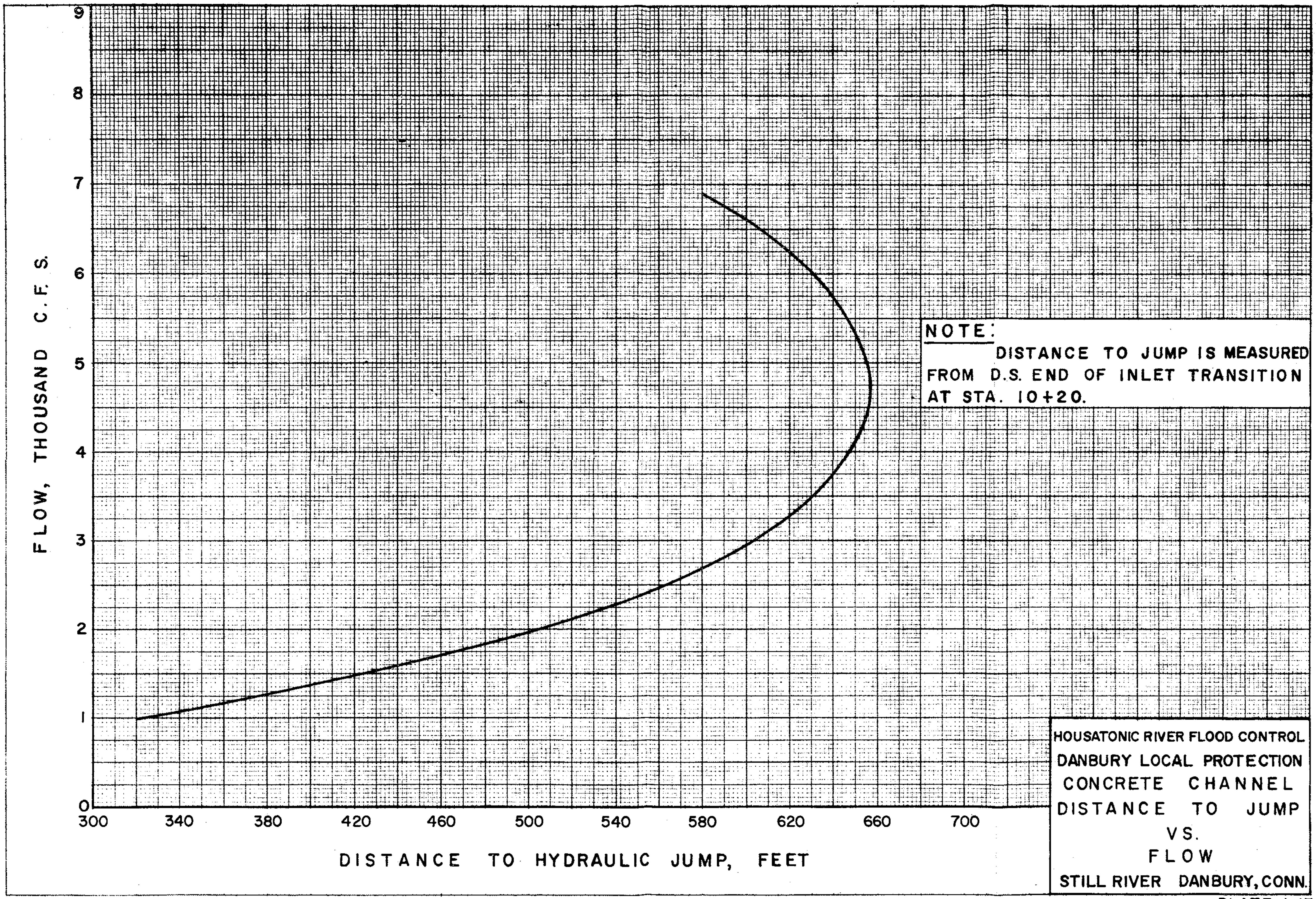
HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

INLET TRANSITION

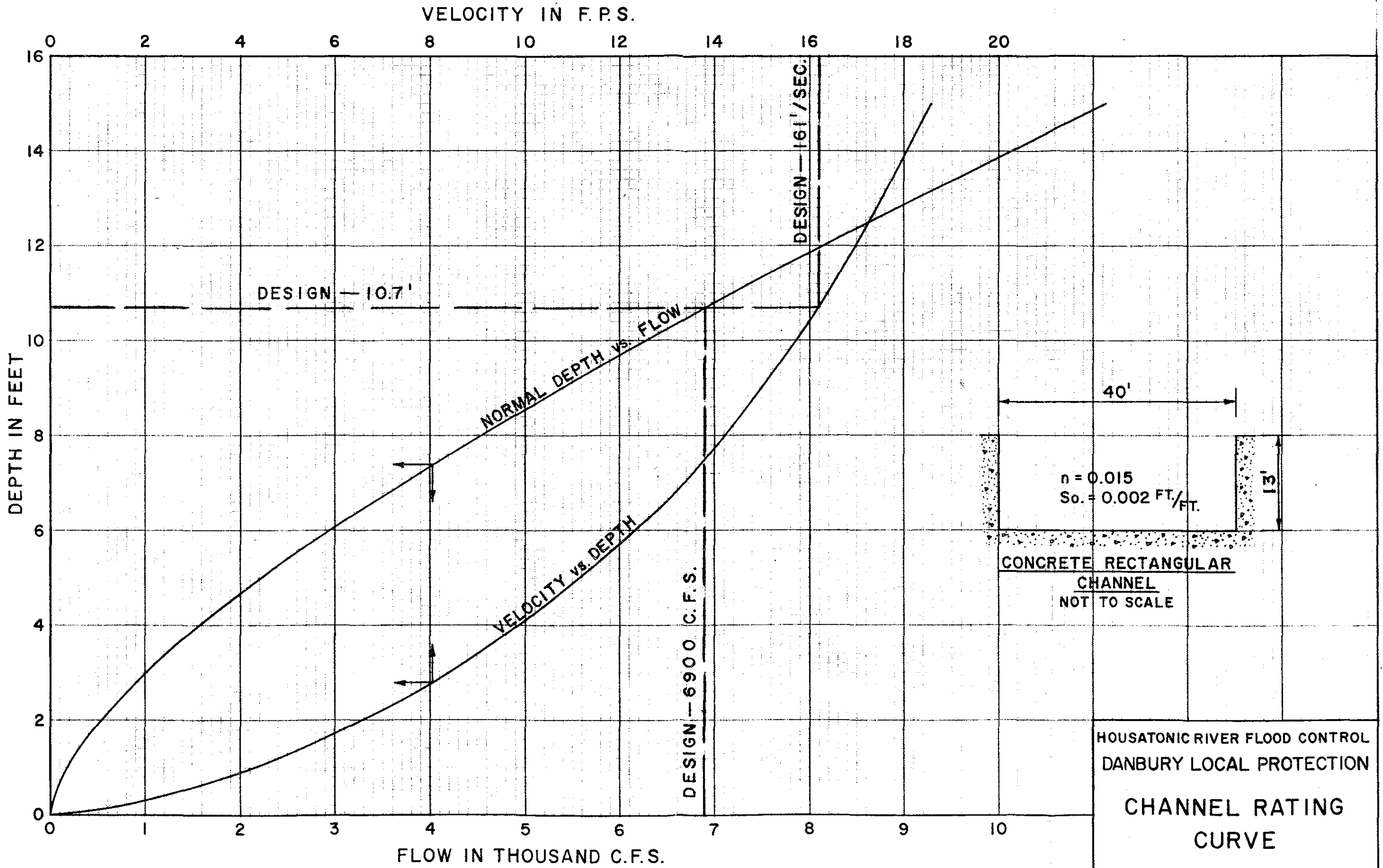
STILL RIVER | DANBURY, CONNECTICUT

PLATE I-16



HOUSATONIC RIVER FLOOD CONTROL
DANBURY LOCAL PROTECTION
CONCRETE CHANNEL
DISTANCE TO JUMP
VS.
FLOW
STILL RIVER DANBURY, CONN.

PLATE I-17

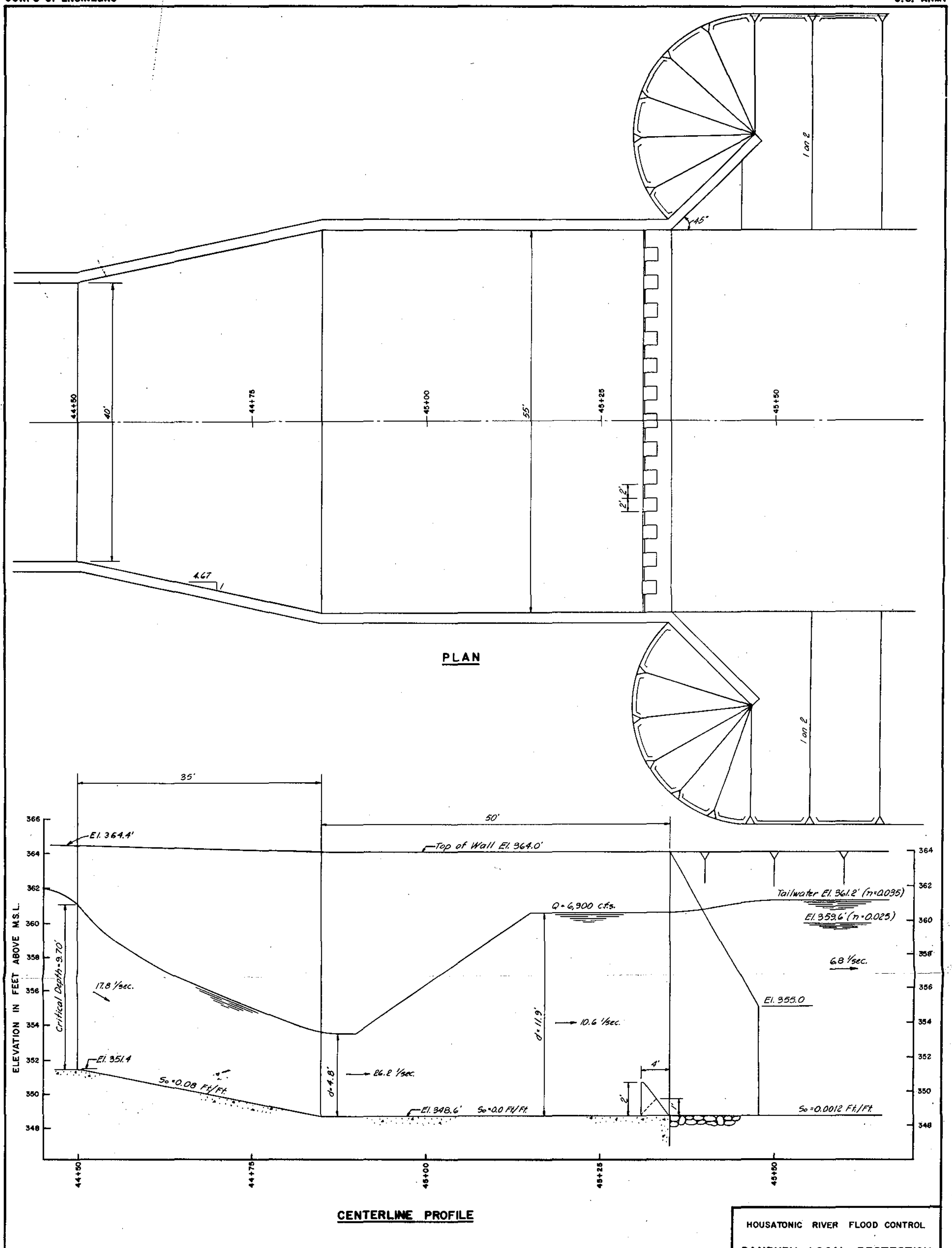


HOUSATONIC RIVER FLOOD CONTROL
DANBURY LOCAL PROTECTION

CHANNEL RATING CURVE

STILL RIVER DANBURY, CONN.

PLATE I-18



CENTERLINE PROFILE

HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION

OUTLET STILLING BASIN

STILL RIVER DANBURY, CONNECTICUT

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION

CORPS OF ENGINEERS, U. S. ARMY

PAGE ______

SUBJECT DANBURY L.P.P.

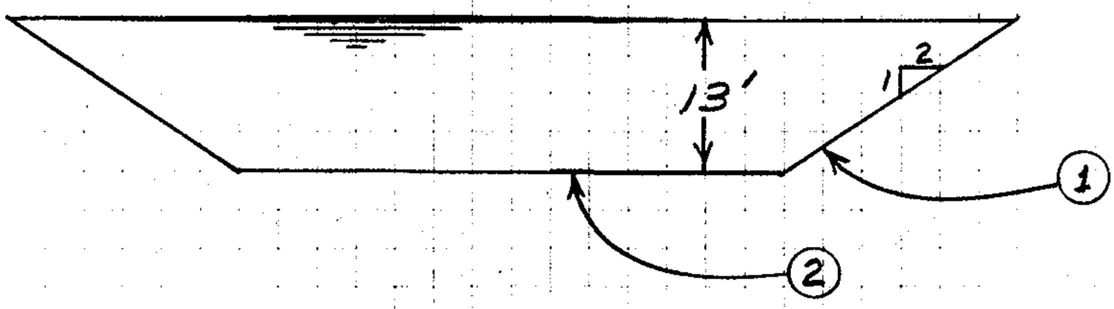
COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S

COMPUTED BY PLM CHECKED BY ______ DATE 6-3-63

STILL RIVER

Q = 6900 CFS

TYPICAL SECTION STA. 46+00 → 49+00



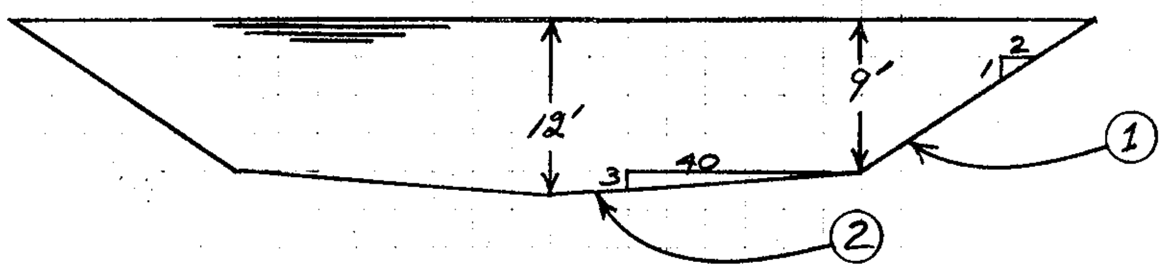
Friction Slope = 0.0020

Depth = 13'

① 1:2 Side Slope, D_{50} = 0.5'

② Flat Bottom, D_{50} = 0.4'

TYPICAL SECTION STA. 49+00 → 67+00

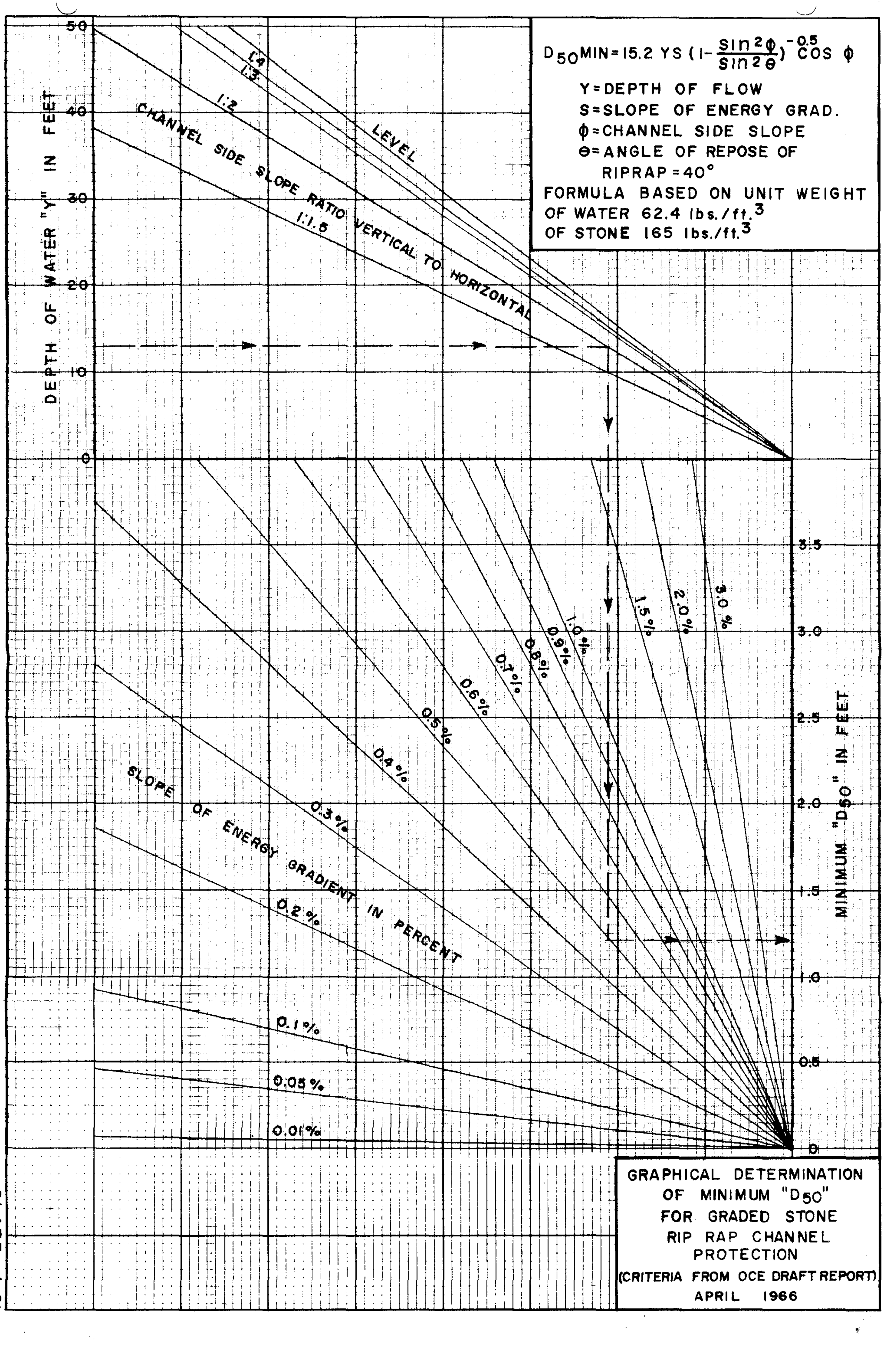


Friction Slope = 0.0020

① Depth = 9', Side Slope 1:2, D_{50} = 0.35'

② Depth = 12', Side Slope 3:40, D_{50} = 0.35'

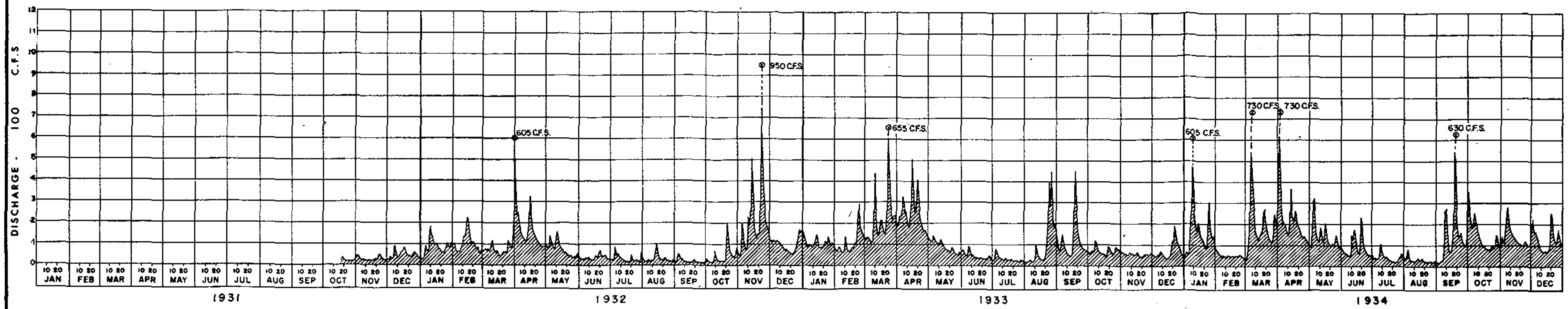
PLATE 1-20

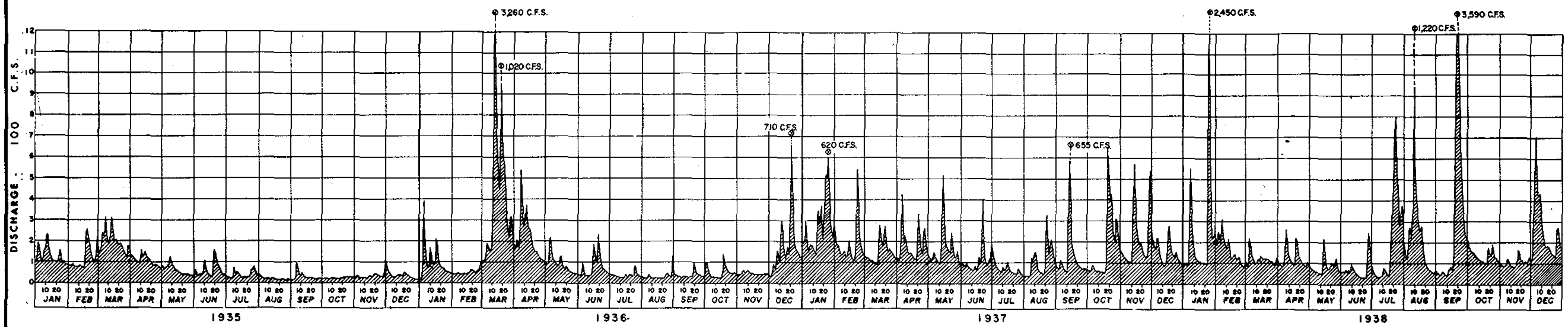


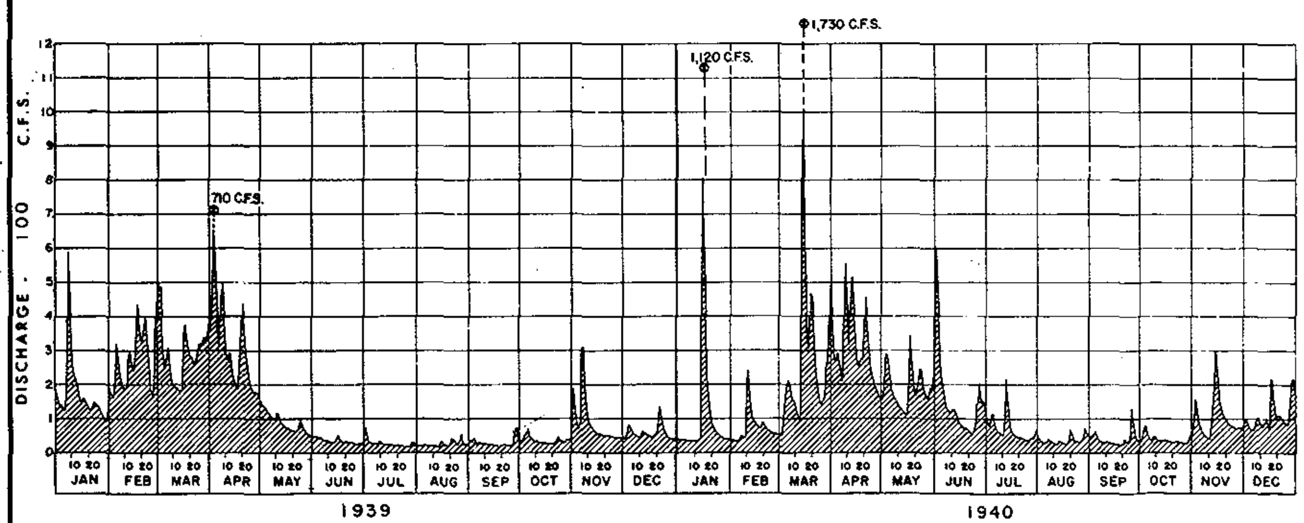
GRAPHICAL DETERMINATION OF MINIMUM "D_{50}" FOR GRADED STONE RIP RAP CHANNEL PROTECTION

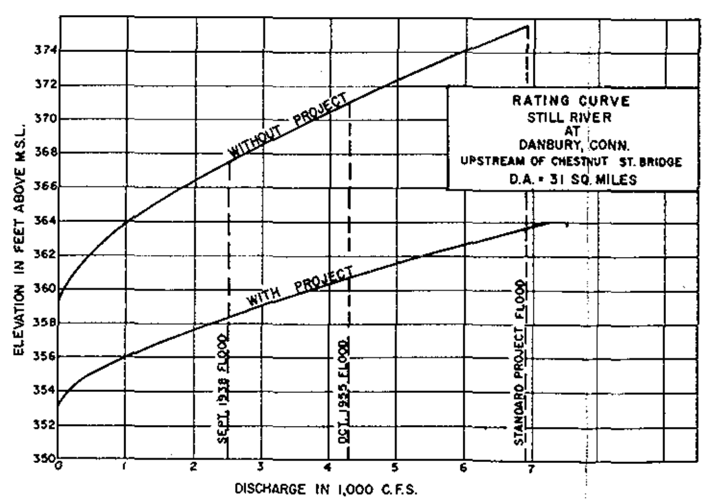
(CRITERIA FROM OCE DRAFT REPORT)

APRIL 1966









NOTES:

1. These Hydrographs Are The Daily Average Streamflow of Still River at Lanesville, Conn. From the Tributary Drainage Area of 68.5 Square Miles. The Drainage Area of the Still River at Danbury, above Sympaug Brk., is 31 Square Miles.
2. Some Instantaneous Peak Discharges Are Shown By – ⊕ .
3. The Data Contained Hereon Are Not Intended As Representations or Warranties But Are Furnished As Information Only. It Is Expressly Understood That The Government Will Not Be Responsible For Any Deduction, Interpretation Or Conclusion Therefrom Made By Any Bidder Or Contractor.

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WALTHAM, MASS

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PROJECT ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANN. & RPTS. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
DANBURY LOCAL PROTECTION
HYDROGRAPHS NO. I
STILL RIVER AT LANESVILLE

STILL RIVER, CONNECTICUT

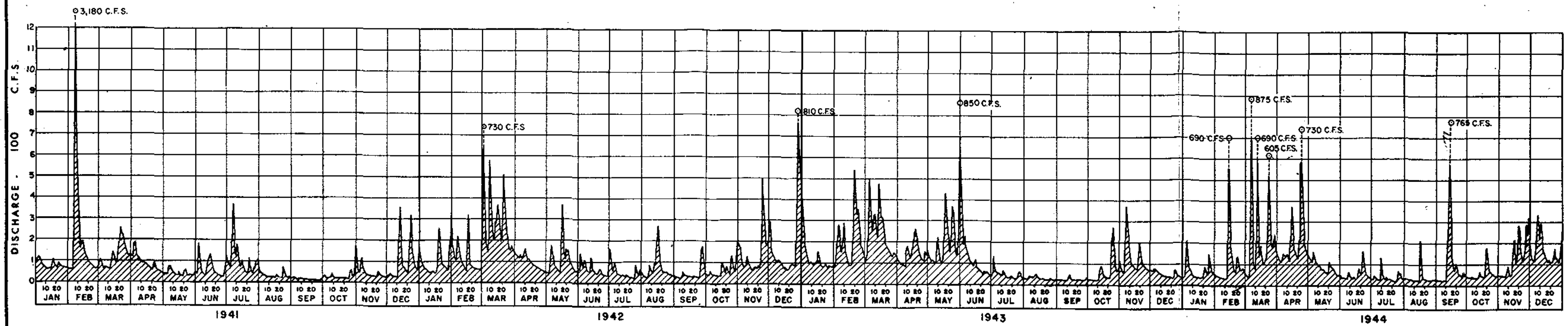
APPROVED: DATE

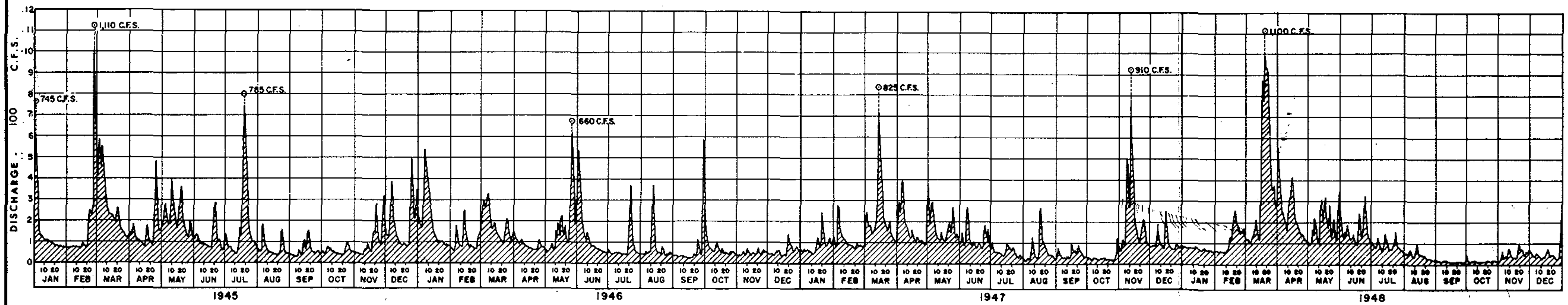
CHIEF, ENGINEERING DIVISION

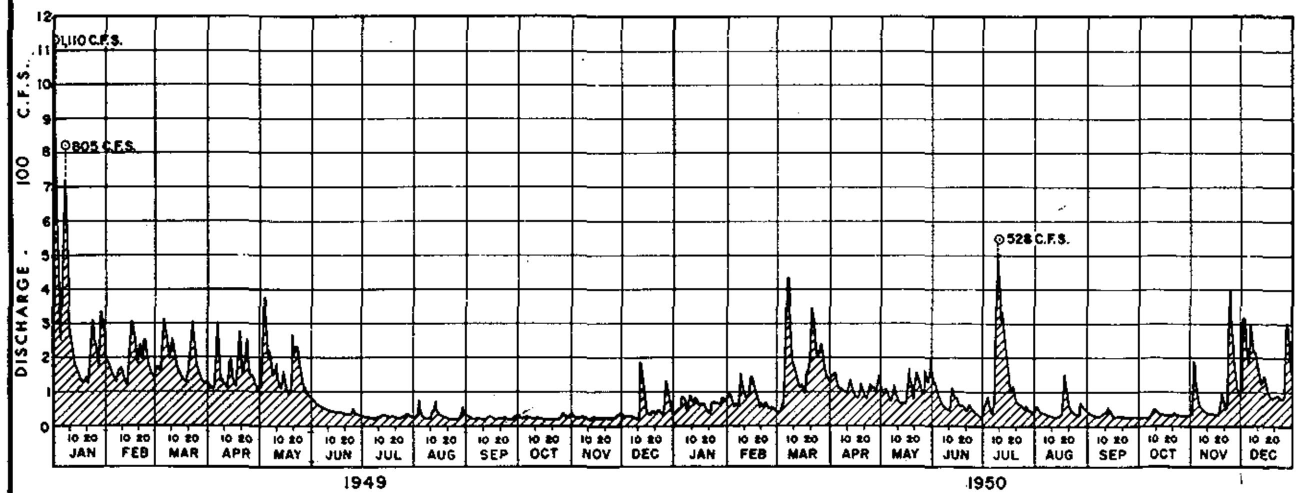
SCALE

DRAWING NUMBER

SHEET







NOTE:
See Hydrographs No. 1 For Notes.

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HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION
HYDROGRAPHS NO. 2
STILL RIVER AT LANESVILLE

STILL RIVER, CONNECTICUT

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SCALE
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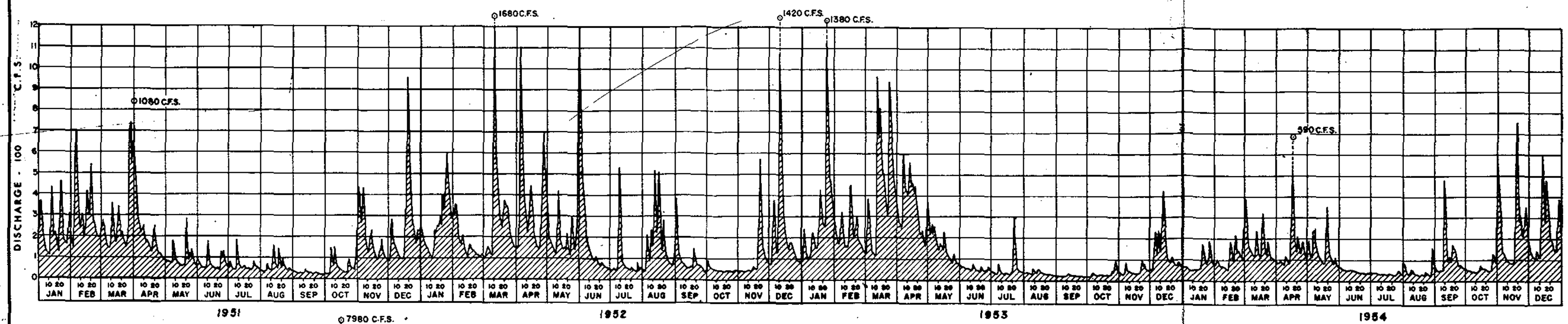

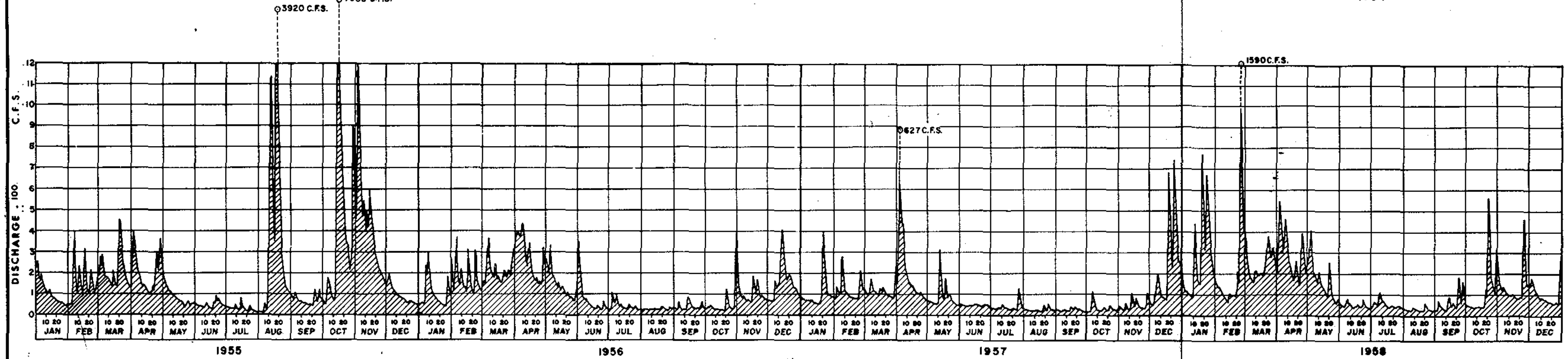

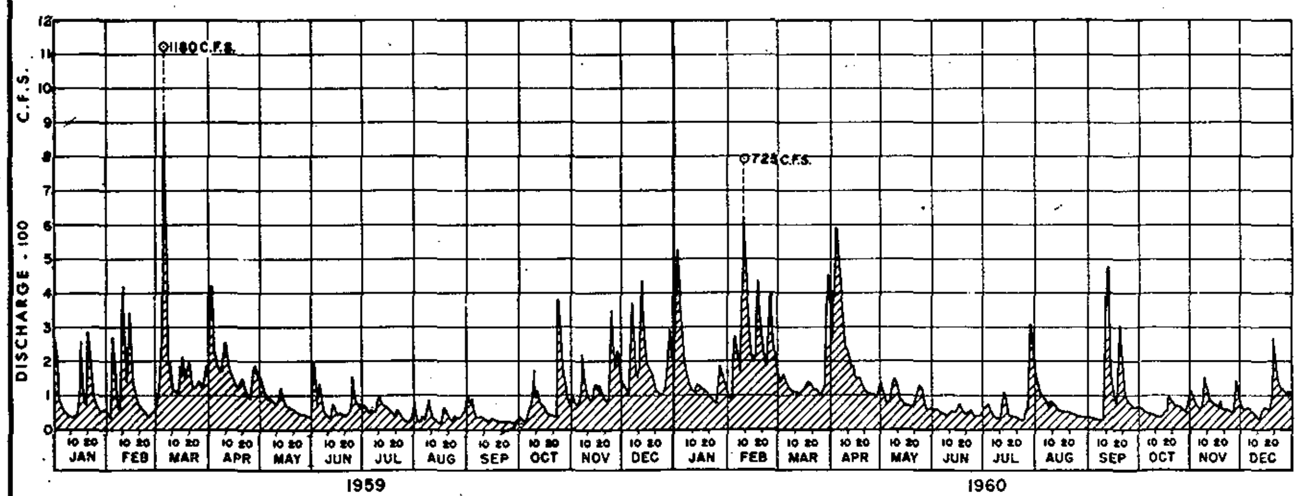

NOTE:

See Hydrographs No. 1 For Notes.

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
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HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION
HYDROGRAPHS NO. 3
STILL RIVER AT LANESVILLE

STILL RIVER, CONNECTICUT

APPROVED DATE

CHIEF, ENGINEERING DIVISION

SCALE

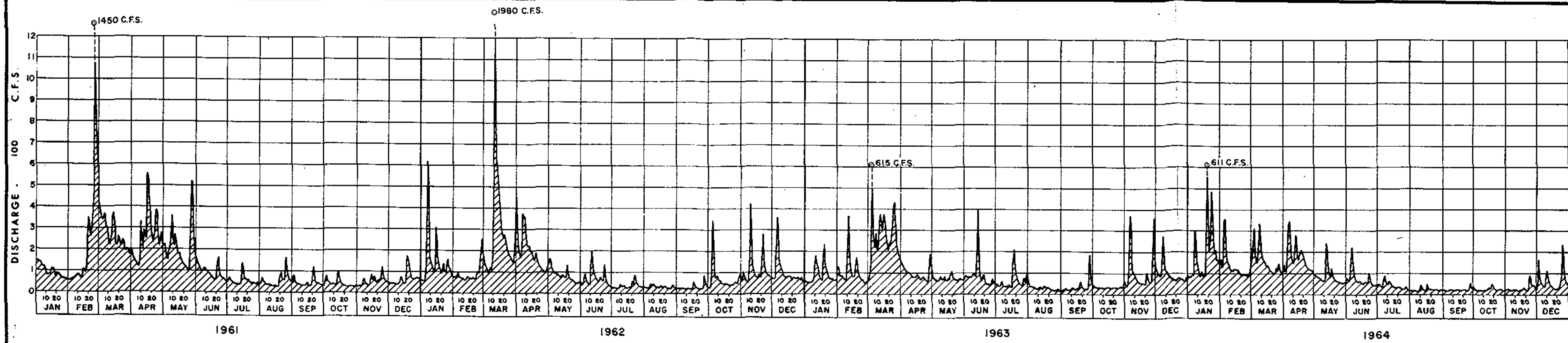
DRAWING NUMBER

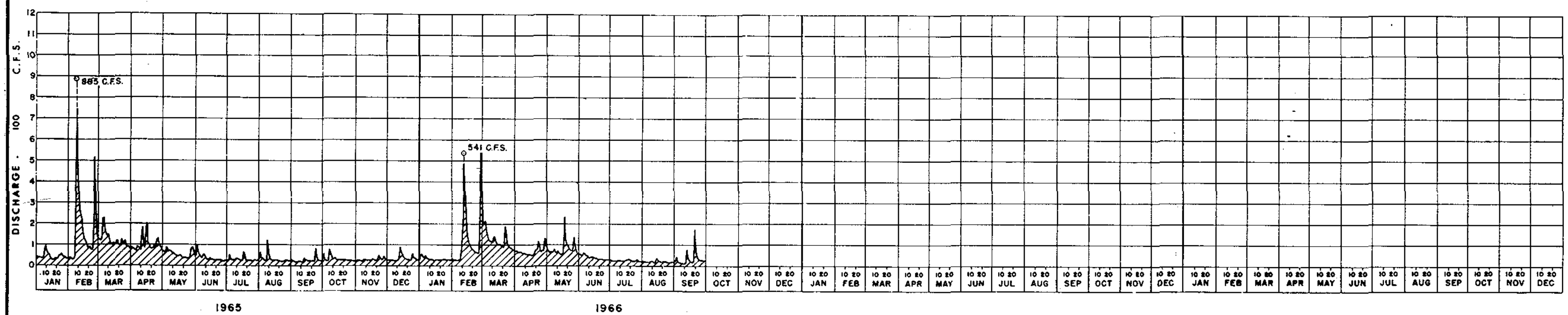
SHEET

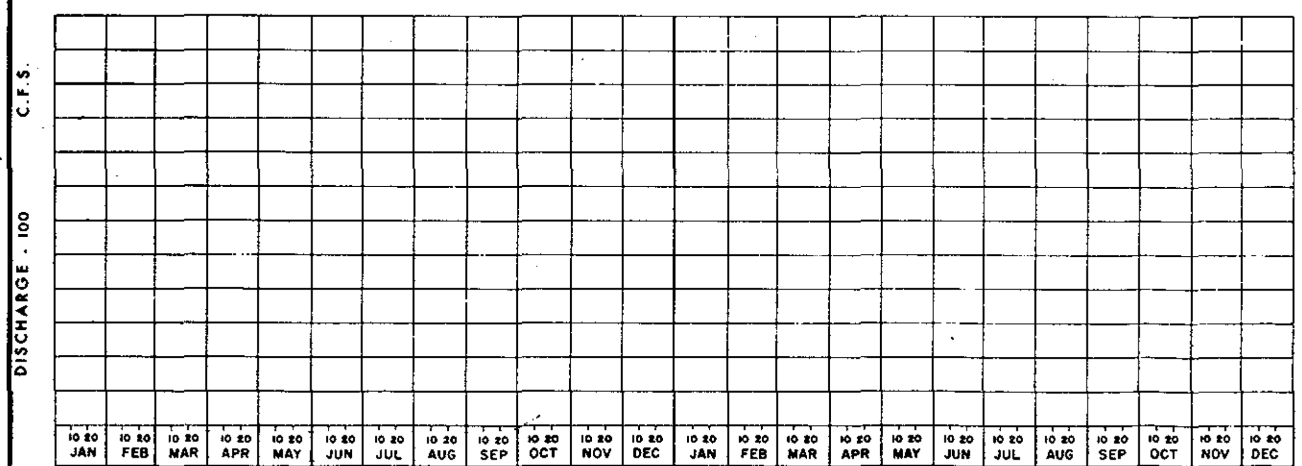
PLATE 1-24

CORPS OF ENGINEERS

U.S. ARMY







NOTE:
See Hydrographs No. I For Notes.

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HOUSATONIC RIVER FLOOD CONTROL

DANBURY LOCAL PROTECTION
HYDROGRAPHS NO. 4
STILL RIVER AT LANESVILLE

STILL RIVER, CONNECTICUT

APPROVED: DATE

CHIEF, ENGINEERING DIVISION

SCALE

DRAWING NUMBER

SHEET

PLATE 1-25